ACCESSIBILITY VALUES IN METROPOLITAN LOCATIONAL PATTERNS

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ABSTRACT OF THE THESIS

Accessibility is only one of the many performance indices which could be applied to a proposed metropolitan locational pattern to test its value to the citizens of the community. A measurement of accessibility requires a systematic description of the metropolitan space economy as a series of interacting activity-elements. A system that is metropolitan in scale should be comprised of elements larger than individual establishments if it is to be manageable. Its elements should be something like "activity-segments", or bundles of establishments that are assumed to act as single "firms" in seeking out their common locations. The system is further simplified by assuming that the metropolis contains only a limited number of different categories of activity segments. The separations between interacting activity-segments can, for the first approximation, be measured in terms of the time of travel between them by the dominant mode of transportation. The index of accessibility for any given "origin segment" relative to any given category of "destination segments" can then be defined as the combination of the time-separations of the closest number of them that are significant to the citizens of the metropolis. Evaluations of these multiple indices must be carried out by those citizens who have a stake in each of them. For a planning analysis these evaluations can be obtained from a series of representative persons selected from each of the major functional groups. Due to competition between many of the activity-segments, these groups may have interests in the accessibility of segments in which they do not actually participate. A hypothetical case study outlines how the evaluations might be organized in a metropolitan locational problem. The basic concepts of the thesis point to many avenues of possible research into the factors underlying metropolitan locational patterns. The concept of accessibility as defined here might possibly form the nucleus for a theory for the development of metropolitan land use patterns.

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MacD. B.

CONTENTS

CONTENTS (cont.)

Chapter I

ACCESSIBILITY AS A PERFORMANCE INDEX

The structure of a metropolis, in terms of the lives of its citizens, is a complex of specialized activity-areas -- the intensively developed spaces that together provide for a vast range of interrelated human activities. The locational pattern of these activity-areas will have a profound effect upon every facet of metropolitan life. Whatever its origins, it will govern both the quantity and quality of the movements between activities that occur in the human life cycles. It will to a large extent determine what activities can be available to any one metropolitan citizen, regardless of the range that is offered in the metropolis as a whole.

There is real need for a better understanding of the meaning of metropolitan locational patterns. Most metropolises in the United States are now growing at near-record rates. The patterns that are currently being set will remain a part of the metropolitan form throughout the forseeable future. They are being shaped not only by the normal play of real estate market forces but also in large measure through the conscious decisions of public officials. The location of a public highway, for example, will affect the metropolitan activity pattern as surely as the location of a river will affect the pattern of vegetation in a desert landscape. Likewise the land use zoning of a municipality, though usually directed toward preserving the existing pattern, will in a negative way guide the location of the growth of less desirable facilities.

Because of the importance of activity locations, public agencies have increasingly been attempting a more positive control of the normal market forces, notably in the current Federal program for urban renewal.

When a public official is called on to evaluate any proposal for expenditure or control instituted by the government of his community, he is obligated to be comprehensive in his estimate of the community's interests. A systematic technique of analysis will be particularly useful in this respect, aiding not only in identifying the significant elements of value in the proposal but also in communicating these qualities in an objective way.

By expressing complex situations through a series of more obvious parameters, a systematic technique will allow the actual evaluation to be much more simple and direct. The process of summation of these detailed value judgements might be adaptable to computing machines once the framework of the analysis had been defined.

What is needed is a series of performance indices that an analyst can apply to each proposal in order to test it against its alternatives in each significant respect. For example, one could test each of the alternative locational plans according to its probable physical coherence as an organic whole, to the efficiency of operation of the circulation system that it might imply or to the sacrifices the community would have to make in realizing it. Through a consistent set of such performance indices one could express in specific terms the actual

"goals complex" of the given metropolitan community.[1]

Of all the performance indices that a community might wish to apply to a metropolitan locational proposal probably the most significant is the measure of accessibility that it provides between the individual activity-areas. The unique quality of a piece of urban land, the major factor underlying its special value, is its accessibility to a wide variety of these specialized activity-areas. In terms of accessibility one can embrace most of the significant economic aspects of a metropolitan locational pattern, and many of its social and aesthetic aspects as well.[2] The particular objective of this thesis is an operational definition of accessibility in terms that will make it a useful performance index for evaluating alternative proposals for future metropolitan locational patterns.

A Systems Analysis of the Space Economy

The most fruitful approach to the analysis of such complex structures as the metropolitan space economy is through the concepts of "systems analysis". One could conceive of the total of metropolitan activities as a system of interacting elements. This would turn the attention first toward defining the properties of the individual activity-areas as elements in the system and second toward relating these properties to interactions between the elements. Biologists have used a parallel approach for understanding the behavior of complex organic systems through a study of the processes within each cell and

their relation to the flows of chemicals between cells.[3]

In a systems analysis, the actual physical locations of the elements are important only through their effects on the interactions. Thus accessibility as a performance index relates not to the physical structure of the metropolis but to the pattern of activities that occurs within that structure -- not to the route of an interaction between two activity-areas but to its speed, cost or other such factors that are vital to the functioning of the areas. Naturally accessibility will be intimately related to the material structure of the channels in which the interaction must take place, but it would be stifling to express the desired performance in terms of that structure itself.

This distinction between the material structure of a metropolis and its performance in terms of activities brings in a critical kind of variable that must be included in any analysis of a social system -- the variations in human values. The neglect of this distinction forms the major drawback of the analytical models that come under the general heading of social physics.[4] It is also the reason why the theories that analyze locational patterns geometrically rather than in terms of human values can seldom be used as tools for evaluating future proposals. Probably the most familiar of these geometrical theories for city development are the concentric-zone hypothesis of Ernest W. Burgess,[5] the sector theory of Homer Hoyt,[6] and the theories of metropolitan form developed by August Losch on the basis of an assumed hexagonal form of market areas.[7]

There may indeed be certain performance indices that do relate directly to the material structure of a metropolis rather than indirectly to the structure in terms of its pattern of activities. An example is the possible index of physical coherence that was mentioned above. However this sort of index is seldom susceptible to systematic analysis. It would hardly be possible to isolate the elements that give an area coherence in the same way that one can isolate the elements that give it accessibility. The performance indices that relate directly to material structure are already in terms which can be evaluated directly without the elaborate sort of operational definition that is attempted in this paper for the index of accessibility.

A Brief Summary of the Thesis

The operational definition of accessibility is attempted in the next following chapter, along with an attempt to express the metropolitan locational pattern in terms of systems analysis. Both of these are very complex quantities. Nevertheless to keep the method of analysis workable two very simplified expressions are suggested - a measure of accessibility in terms of time of travel and a representation of the locational pattern in terms of a fairly gross scale of "activity-segments".

Having posed the locational problem, we are led to the subsequent step of formulating a method for evaluating locational variations. The suggestion made in Chapter 3 is that each index of accessibility be evaluated directly through such techniques as selected polling of the groups

to which it is of major concern. The remainder of the chapter contains a listing of four major factors that would affect the value of various types of accessibility to these groups, along with a few minor factors that might also be considered.

Even with the great simplifications in the index of accessibility, the fact that so many different groups are concerned tremendously complicates the problem of evaluation. Chapter 4 turns first to the solutions devised by welfare economics theorists for an insight into methods of simplifying these value estimates. The result is a series of four major limitations that it is suggested be placed on the evaluation procedure: a limit on the different groups whose interests are considered, a limiting of the time-of-travel measurements to discrete variations, a limit on the number of different kinds of activities in a metropolis, and a limit on the number of time-of-travel measurements used in constructing each accessibility index.

Because the ultimate aim is a method that will be operationally useful, the thesis concludes with a hypothetical example of how these concepts might be applied to a specific metropolitan locational problem. Although there was an attempt to keep close to a realistic definition of activity-areas for the sample metropolis, the suggested locational patterns are extremely simplified, each being completely symmetrical. The objective was a minimum of computations, but correspondingly many of the subtile values that an accessibility analysis might point up have been lost in this oversimplified example. Still, reference to these

more detailed factors is made throughout the text.

Chapter 6 following the case study lists some of the refinements that might be made upon the concept of accessibility as it has been presented here, especially to take account of the other aspects of the form of a metropolis that are interrelated with the locational pattern. Along with these is a suggestion of how one might construct, from this concept of accessibility, a theory for predicting the normal trends of metropolitan growth.

This last suggestion emphasizes again that this thesis does not attempt any real theory of urban values. The analytical tool that is proposed still involves only a very partial analysis; any future plan would have to be tested against many other types of performance indices before one could reach anything like a comprehensive evaluation. The framework for analysis that has been suggested could only become meaningful when filled out with the actual value judgements of some specific community. Even then its predictions would only express in partial terms the usefulness to that community of various locational alternatives that might or might not someday be realized.

Chapter 2

POSING THE METROPOLITAN LOCATIONAL PROBLEM

Accessibility at the metropolitan scale can be defined as the inverse of the separation or "friction of space" between each pair of interrelated activity-areas. In constructing an index of the accessibility of one area from another, one should ideally include measures of nearness in terms of time, cost, physical and social distance. These in turn would depend upon a great many of the characteristics of the trips between the areas, ranging from the congestion on the streets or parking spaces to the aesthetic qualities of the areas traversed.[8]

Constructing such an all-inclusive index would be extremely difficult, even for an existing situation that was available for field checks. Physical distance could of course be measured directly. Time and cost however would vary with the particular vehicle and operator, and social distance even with the personality of the traveller. All of them would vary with the selection of the route for the trip and probably with the time of day. Even if one could resolve these many variations and determine some meaningful averages for each of the four measurements of separation, there would still be the problem of weighting them against each other. Ideally this weighting itself should vary with the nature of the interaction between each specific pair of activity-areas. For example, time would probably be the dominant factor in the separation of home from work, while cost might be more important in an interaction

involving the shipment of non-perishable commodities.

When the analyst is asked to measure the separation of activity-areas in a proposed future locational pattern, where separations can only be inferred from other properties of the pattern, the problems of constructing an accessibility index become compounded. Therefore it is suggested that for the first approximations time of travel will be the most significant single measurement of separation;[9] it is the only measurement used in the sample analysis of Chapter 6. It should include of course the time expended at the terminals of the trip for such things as loading, unloading or parking the vehicle.

To combine the time measurements for the various routes of travel that might be selected between any two activity-areas one could weight each of them according to the proportion of the total of interactions which followed that route. The time measurements might be further modified to account for consistent differences in the effects of each mode of transport -- for example, the unique value that apparently is almost always derived from driving one's own automobile. As for variations in the time-separations with the time of day, one could study two or three typical conditions of the load on the circulation system, such as "sparse", "normal", and "rush". The importance of each of these for the index of each separation would again depend upon the proportion of the total daily interactions that fell into that category.

Establishments and their Linkages

From this very simplified definition of the performance index of accessibility one can proceed to specify the activity-areas whose time-separations are to be measured. The basic activity elements in an urban space-economy system, the units that set the pattern of urban activities, are the individual "establishments". Operationally, an establishment is defined as a packet of functions gathered together at a single place within one decision-making unit. It is free to locate wherever in the available real estate it can strike the best balance between its own needs and the rent it must pay. This definition would include households, single business firms, single branches of larger business firms, and institutions of all kinds.[10]

For any group of units that form a system the interactions between those elements are the critical variables, not only determining the level of activity in each of the elements but also having certain requirements for their own channels. Interactions between establishments in the space-economy system might take the form of flows of people, flows of goods in vehicles, flows of fluids either in channels or uncontrolled in the atmosphere or across the ground surface, flows of electricity, flows of information, or even flows of sound waves or electromagnetic waves. The interactions which are controlled and which have a close relationship with the metropolitan locational pattern are referred to as "linkages", a term that has been defined as follows by Mitchell and Rapkin.[11]

> "Linkage, then, may be defined as a relationship between establishments characterized by continuing or frequently recurring interaction. It is associated with the movement of persons and goods between the linked establishments and generates a tendency on the part of linked establishments to seek proximate locations."

These needs for "mutual proximity" or accessibility are the basic systematic forces that must be accomodated by the metropolitan locational pattern. They will be balanced of course by the many other more random needs of the various establishments and by limitations on space of the desired quality and on each establishment's rent-paying capacity.[12] They are the strategic variables that must be objectified in any theory for the metropolitan space-economy.

Though the concept of interacting establishments may be the most reasonable and obvious approach to understanding an urban space economy, it must somehow be simplified when one works at a metropolitan scale. There are just too many establishments in a metropolis to be handled individually in any integrated analysis. In the "core area" of Philadelphia alone there were over 20 thousand non-residential establishments in 1949;[13] for the entire metropolis the figure would be much larger, and to it would have to be added the more than one million individual households. The quantity is so vast that John Rannells was forced to limit the measurements in his study of the core area to just the spatial "coincidence" of several categories of establishments, touching only subjectively on the linkages that he recognized as the basic forces generating these spatial patterns.[14]

The necessity of simplifying the system by using something more general than establishments as the basic elements can be seen throughout the processes of metropolitan planning. In the analysis stage, the interactions of each separate element alone would form a very complex expression, as is evident in any sophisticated location study for a single industrial or commercial establishment. In the design or policy formulating stage, there is a limit to the number of separate interacting elements that can be comprehended as a single system by the human mind. A complicated problem like the locational pattern of an entire metropolitan area normally would be simplified into a hierarchy of systems within systems. The general unifying system at the largest scale in such a hierarchy might have as its individual elements whole sectors of metropolitan activities. Finally, in the effectuation stage, the zoning controls through which a metropolitan land use plan may be realized traditionally apply uniformly throughout each kind of area without discriminating between establishments.

Activity-Segments of a Larger Scale

There should be some solace for metropolitan planners in the fact that as cities grow to a metropolitan scale there do actually appear whole areas that become more and more uniformly devoted to some specialized use. When a particular location has advantages on a metropolitan scale for some special activity, more and more establishments of that kind tend to gather there, forming the familiar clusters of factories in industrial belts or "estates", clusters of homes in residential neighborhoods, clusters of

offices in financial districts, and clusters of night-spots in the entertainment section, to mention only a few. Such clusters might range in size from the few buildings of a civic center to the many square miles of the larger residential subdivisions or of a regional park.

Furthermore there may be forces tying these specialized activity areas together as more than just a fortuitous gathering of establishments having similar metropolitan relationships. The establishments may be united into a single complex either by direct linkages such as the need for face-to-face contacts in an office district, or by localization economies such as the joint use of some larger and more efficient service facility, or perhaps by common linkage with a larger complex such as that which ties a cluster of neighborhood stores to its residential section.

Occasionally the forces creating a cluster of establishments will be arbitrary and should not be taken as an indication of any economic bond. For example, establishments may be forced together by having only limited pockets of land suitable for certain kinds of structures, or by arbitrary zoning restrictions.

In the light of the above considerations, it is assumed for this analysis that all the establishments of any metropolitan area can be grouped into a series of "activity-segments. Thus each segment is both an element in the metropolitan activity-pattern and also a bundle of specific physical forms that can be described by dimensions such as land area, floor space, or capacity for participants. Locational needs,

including linkages, will be estimated for activity-segments as a whole rather than for each establishment within them. In the language of industrial location theory, each segment is assumed to act as a single "firm", i.e. a single decision making unit.

The size of activity-segments utilized in a planning analysis will have a real bearing on both the difficulty of the study and the accuracy of its results. One is tempted to make them as large as possible to minimize the effects of random variables such as local topography and to keep the cost of the analysis within the usual limitations on a planning agency's budget. However, as the segments become larger, more and more of the actual linkages between individual establishments become lost in the systematic expression, gradually reducing its accuracy. The size of segments used for the hypothetical metropolis of 100,000 population outlined in Chapter 5 varies between residential segments housing 2500 persons each and the business district that daily draws over 19,000 workers plus an untold number of shoppers and other visitors. These segments are really too large to lead to any accurate analysis.

This definition of activity-segments should be handled with care; two of its implications are particularly questionable. First, it allows no overlapping or blending of two activities along the fringes of their segments; each is a separate region delimited by a definite boundary. This was felt to be a necessary sacrifice due to the need for information on each activity-segment as a separate unit. The obvious mixtures that appear along the fringes of activity-areas in reality will have to be

considered as localized boundary conditions that don't affect the linkages of each segment as a whole.[15]

Second, and more significant, this definition implies a uniformity among all the establishments of each segment in all of their locational needs. The linkages of the entire group must be expressed as if it were homogeneous. This uniformity must hold even for establishments along the edges of each segment, which might be as close to the center of another activity-segment as to the center of their own. In applying this concept of a system of interacting activity-segments to real situations, the definition of its terms must be extremely sensitive to these two implications.

The Total Pattern of Activity-Segments

When an individual segment is being examined to find the value to the community of its various kinds of accessibility, it will be termed an "origin-segment"; when it is being considered as an area whose nearness to other activities is desired, it will be termed a "destination-segment". Where an activity-segment is large, the time-separation is probably best measured from the "center of gravity" of its dominant activity. Naturally there won't be a value correlated with every single time-separation -- for example it matters little how accessible a warehouse district is from a regional park. Still, the value of each time-separation should be separately considered, even if the resulting correlation is zero.

Thus, with every activity-segment considered both as an origin segment and a destination-segment in turn, measurements are made of the

time separation between every significant pair of activity segments rather than purely of the separation of each one individually from some one or a few specified "core areas".[16] This multiplicity of accessibilities is becoming increasingly important in the rapidly developing fringe areas far from the central core of the metropolis, where one of the alternatives (and often the reality) is a scattering of different focal activity-areas without any one balanced nucleus.

Before completely focusing attention on the pattern of activity segments at the metropolitan scale, some account must be taken of the effects of patterns that appear at every other scale in the hierarchy of the space economy. First, to avoid complications due to variations in patterns of activity outside the metropolis, it would be helpful to assume that these have no effect on the value of an intra-metropolitan locational pattern. With relation to the rural land along the metropolitan fringe, this assumption may be fairly accurate. The low intensity of activity on this land as compared to the adjacent urban areas places it in a quite different scale of space economy. Its value is determined through competition with other lands that stretch across a metropolitan hinterland far more extensive than the urbanized area.[17] However, with relation to nearby concentrations of urban activity this assumption would be less valid. Especially when these concentrations are large and are accessible by high-speed transportation, it may be necessary to study their special linkages with certain of the activity-segments of the metropolis.

On the other hand the value of any particular metropolitan-scale locational pattern will depend significantly upon the internal properties of the individual activity-segments, involving both the magnitude of the functions concentrated therein and the physical structure of the segment that provides for these functions. Variations in these properties might have a direct value in their own right as well as an effect on the value of the overall locational pattern. It might indeed be possible to account for both kinds of effects by expressing such variations in terms of still further performance indices. For example, there could be indices expressing the quality of the light and air that penetrated the buildings of each activity-segment, or the capacity in numbers of people of the public assembly halls in the central activity-segments. However the particular emphasis in this thesis is on accessibility values arising purely from locational patterns. Thus all the other variables that would affect the accessibility index, such as for example the techniques of transportation or the land area of the individual segments, are assumed to be constant throughout the remainder of this analysis and in the following case study.

Thus each of the individual segments is assumed to be a constant element whose properties are unchanged in the various alternative locational plans that are considered. In other words, it is assumed that there are no further substitutions between the "locational inputs" and any other inputs consumed by any of the metropolitan activities.[18] With such an assumption, the obvious diversity that exists among activity-areas of every kind will have to be incorporated in the definition of activity-segments

prior to the accessibility analysis. Since such characteristics as higher density relative to surrounding segments will mean stronger linkages per unit area, the higher density segments will have a built-in advantage for usurping the more central locations. Thus a great deal of the relative value of any one locational pattern would depend on the initial definition of activity segments, a process that must be completed before the accessibility analysis can even begin. This initial definition would in fact set the total range of activities available, or in a sense the breadth of the metropolitan culture.

The assumptions of this chapter bring the metropolitan locational problem into a form that is fairly susceptible to a systematic accessibility analysis. Only variations in the locations of a fairly gross sort of activity-segments would be comprehended; all other factors would be assumed constant. The following chapter now turns to the question of how one might determine the value a metropolitan community might place on each of these locational variations.

The proposed method can be systematic and objective only as an analytical tool. Each of the patterns to be analyzed must still be the result of a process of creative design. Even if one could formulate a consistent complex of the community's goals for each of the activity segments, it would be impossible to construct a conceptual model that could predict or generate an optimum pattern to satisfy those goals except by the process of trial and error.[19] Still, a clearly formulated analytical method is

an invaluable aid in the design process. By giving the designer a feeling for the effects of each change he might make in the plan, it can point the way toward a more meaningful end product.

Chapter 3

DETERMINING THE COMMUNITY'S EVALUATION OF ACCESSIBILITY

It has been proposed in the preceding chapters that the accessibility between individual activity-segments of a metropolis, measured in terms of their time-separation, is a useful indicator of the value of a metropolitan locational pattern. One is immediately faced with the questions of first, how to determine what value the citizens of a community would actually place on each possible level of each time-separation and second, how to amalgamate these individual evaluations into a general community evaluation for each pattern as a whole.

Some Alternative Techniques for Evaluation

One of the simplest methods would be to assume that the community desired to have a minimum of total passenger-hours spent in the process of travelling, regardless of the particular nature of each trip. Such a criterion would necessarily have to be accompanied by the assumption that the total number of trips between each pair of activity-segments was more or less constant, and that only the duration of each trip might vary. Otherwise it would suggest that the segments should be scattered to the four corners of the globe, in order to reduce the probable passenger-hours spent travelling between them to approximately zero.

Even with the assumption that the number of trips between activity-segments stayed more or less constant, this minimization of total travel

time would be insufficient as an indicator of accessibility values. For example there are no doubt many industrial workers who derive a real benefit in terms of wages from the competition for their services of at least two factories readily accessible to their homes, even though they never spend a minute in travelling to more than one of them.

There are several such factors underlying accessibility values that extend beyond the costs of movement per se. An attempted outline of them appears in the following pages. Still the number of passenger hours spent in each interaction might be used as a base measure of the costs involved, with these further factors considered as modifiers.

Since there is a significant correlation between the accessibility of a piece of urban land and the rent that it will bring, it has often been suggested that rent can thus be used as an indicator of accessibility. One of the first to express this idea was Robert M. Haig.[20]

> "Site rentals are charges which can be made for sites where accessibility may be had at comparatively low transportation costs. While transportation overcomes (space) friction, site rentals plus transportation costs represent the social cost of what friction remains.
>
> . . . . . .
>
> Of two cities, otherwise alike, the better planned, from the economic point of view, is the one in which the costs of friction are less. This will mean that the aggregate site rents are less, or the transportation system is superior, or both."

However to use this correlation as a tool for evaluating accessibility would grossly oversimplify the meaning of rent. Land values may arise from a number of other factors, such as topography, conditions for

building or social identity, that may or may not be present in the given metropolis. Even the transportation system itself might create high rents for a certain area not only by reducing the cost (or time) of travel to that area but also by concentrating the flows of people in certain channels to generate what is normally called "impact trade". For example much of the retail trade in the "core area" of a metropolis, and the corresponding high rents for those retail sites, results from the heavy concentration of pedestrians travelling on the sidewalk in front of the display windows. These concentrations need not depend on the ease with which the pedestrian can reach that particular point, but may instead result from the particular structure of the metropolitan transportation system. Naturally these two factors are not completely independent, but neither are they closely enough correlated to make rent a reliable indicator of accessibility.

Even if rent could be reliably correlated with accessibility, its use as a planning tool would require complicated estimates of the total of rents that future locational proposals might draw. These would amount to a detailed appraisal of the values that would accrue to the owners of each separate parcel of urban land in each of the alternative plans. If such careful studies were to be made of the location of each segment, it would seem worthwhile to invest a somewhat greater effort to find the value of its location to <u>all</u> of the interested citizens in the community rather than just to the owners of the land.

Such an appraisal would have to be carried out in a very sophisticated way. It would have to reach to each citizen in the community who had a significant interest in each kind of accessibility for each of the activity-segments. Obtaining such direct subjective evaluations by the citizens of the community would be no easy matter; nevertheless the importance of the metropolitan locational problems warrants a sizable research investment. Several methods of simplifying the task are considered in the following chapter. Meanwhile the remainder of this chapter is devoted to outlining the factors which would probably be most significant in the accessibility evaluations.

The Factors Underlying Accessibility Values

Costs of movement are the basic determinant of accessibility values, but their effects will depend on a number of further factors of the kind listed below. Movement per se will involve two different sorts of costs: the operational costs of the vehicle and the channel in which it moves, and the effects of the movement on the traveller or on the goods being shipped. For the former a measure of the space-separation of the activity segments would be valuable. Still, time-separation alone will be a fairly good index, especially for such costs as employees wages or wear on any equipment operating at a steady rate during the movement without relation to speed (e.g. a car's lighting system).

Time-separation is a quite good indicator of the effects of the process of movement on the traveller or the goods. For the traveller this would include his investment in terms of opportunities for other activities

that must be forsaken and in terms of the psychological impact of the movement. These are both critical factors. For the goods, on the other hand, time-separation would indicate the costs of idleness of the material investment.

A range of choice of destinations will have a value that depends on the nature of both the origin segment and the destination segment. The need for choice will have the effect of increasing the value of accessibility to segments to which little or no actual movement occurs. Accessibility to such segments would depend on the same factors as costs of movement — thus time-separation should be a fairly adequate index.

A range of choice might be valuable in several different ways. First, it allows selectivity among destination segments when there are differences in the goods or services that they offer, as for example in the films offered by various movie houses. Second, it gives a security in the location of the origin segment when there is a risk of sometime having to make a switch between destination segments for some critical kind of linkage, as a worker may have to do if he loses his job. Also there is often a value in choice to a buyer, allowing him to bargain between a variety of sellers to obtain minimum competitive prices.

Spatial monopoly is the converse of range of choice; its value to a seller will arise through its affording him a somewhat captive market. The desire of a seller for spatial monopoly will be expressed through his placing a high value on his customers' accessibility to himself but a correspondingly low value on his customers' accessibility to any

competitor. Thus the accessibility of any given activity-segment may be the concern not only of the direct participants in the activity of that segment but also of the merchants or employers competing for an interaction with those participants.[21]

Spontaneous interactions will demand a higher order of accessibility than those for which the movement can be carefully planned in advance.[22] Thus, compared to the frequency of the interaction, there is usually a higher value in access to a place for spontaneous outdoor games or for emergency medical treatment than in access to the habitual work place.

These four factors are felt to be the major determinants of the value of any particular pattern of accessibilities to the citizens of a community. There are at least two other factors that are more important on the intra-segment scale and that are probably more closely correlated with other indices such as physical distance than with time-separation. However, in evaluating shortest order of time-separations their effects should not be neglected.

There may be impacts of concentrated population movements resulting from one's easy access from a segment containing an unusually high concentration of participants. These impacts may have either a positive or a negative value, depending on whether the people are a benefit to trade or a hindrance. Their location will depend largely on the structure of metropolitan traffic; they will to a large degree offset the spatial monopoly values that might otherwise lead to a dispersion of commercial facilities.

There may also be a value placed on time-separation that arises through a desire of the origin segment for an identification with the destination segment. Though accessibility may be a necessary condition for this sort of identification, it is far from a sufficient condition, as can frequently be seen in the nearness of the "gold coast" in many cities to a slum area.

To evaluate the whole range of time-separations implied by any given plan in terms of all of these factors for all of the metropolitan citizenry would be a Herculean task. Somehow the number of evaluations must be narrowed down to the most significant few. The following chapter outlines a series of simplifying assumptions that might bring the problem within the scope of the usual metropolitan land use study.

Chapter 4

SIMPLIFYING THE EVALUATION PROCEDURE

It has been postulated that there are certain values of the citizens in any given metropolitan community that can be associated with each variation of the performance index of accessibility, or indeed with any of the other performance indices used in this sense. Values are in their very essence subjective, and a great deal of caution must be used in any attempt to express them systematically. The problems of constructing theoretical expressions of values have been plaguing the field of welfare economics for decades.[23] The way in which the welfare economists have handled two of the major difficulties of value theory can give useful insights into the problem at hand.

The General Problem of Expressing Community Values

In the first place, if the community's values are a logical construction of the values of its individual citizens, how can one express them consistently when individuals may not only act irrationally in an economic sense but are constantly changing their roles in the community both in a cyclical and a secular way? Secondly, even if one could determine the "satisfactions" derived by each individual from some community proposal, how could these individual satisfactions be combined to find the total level of satisfaction of the community? A mere summation of satisfactions would require giving each of them a quantitative value --

a very difficult procedure indeed.

Facing either of these problems forces the analyst to make certain assumptions; concerning the first, a suggestion by I.M.D. Little is pertinent.[24]

> "Most people who consider the welfare of society do not, I am sure, think of it as a logical construction from the welfare of individuals. They think rather in terms of social or economic groups, or in terms of average, or representative, men. Now it is evident that representative men are very much more like economic men than are real individuals. The tastes of an average man do not change at all rapidly . . . . . The average unmarried male cotton operative will not, for instance, suddenly alter the pattern of his consumption by getting married. . . . Much more important, he never dies."

Obviously, the fewer the representative groups that must be consulted in relation to any given situation, the simpler will be the process of evaluation. There is a danger in taking this generalized approach to the needs of the individual that no allowance will be made for the desires of the deviants; but the approach is necessary for any systematic analysis.

The welfare economists, as represented by Little, have tried to avoid the need to quantify individual satisfactions by suggesting that values be specified by means of an ordinal rather than a cardinal number system. That is, they would evaluate alternatives merely by order of preference rather than by assigning a quantitative value to each. Thus having a preferred alternative would mean merely being "in a chosen position", without any explicit measure of satisfaction.[25]

Though the idea of an ordinal value system is quite attractive in theory, it could be applied only in the analysis of very simple

situations. Its limitation lies in that it requires a ranking of every separate combination of the available alternatives for which a person might expend his resources in relation to every other combination. Even when the planning problem is limited to the context of a specific time and place, there will be thousands of alternatives that a plan could provide for each individual, even for a generalized "economic man". This would mean literally millions of separate combinations of alternatives to be judged for each different kind of individual. When alternatives open to the community are in turn expressed as various combinations of the alternatives open to the individuals, the number of separate combinations possible (each of which would have to be separately judged) increases in a geometrical ratio with the number of individuals. To attempt such an estimate of community preferences within the limitations of an ordinal number system would be like running a modern business on the principle of barter exchange, without the quantitative monetary value system.

These statistical considerations hold two important lessons for those who would estimate the welfare of a community in terms of the welfare of its individual citizens, especially when the theory is to be general in time and space. First, individuals should be considered only as members of a minimum number of different groups of "representative men". Second, satisfactions derived by these groups in different realms of their existence should be assumed independent of those derived in other realms; the more the analyst can separate a man's choices into independent realms, the fewer will be the alternative combinations to be

evaluated.[26]

Groups with Interests in Accessibility

In the previous chapter it was suggested that in the analysis of activity-segment locations one should consider every citizen in the community whose special interests were involved. It would seem most valid to base the representative groupings of these individuals on the functional roles of people within the activities of each segment. In the case study of Chapter 5 a very simplified breakdown of five different functional groups has been used: residents, workers, employers, customers, and merchants. Most individuals would be participants in several such groups.

Each of these groups exists only as a proportion of the participants of some one or another particular activity-segment. With a fairly detailed accounting of the groups directly involved in each activity-segment one could actually comprehend a good deal of variety in its make-up. Of course not every group would be significant in every segment, and indeed in the case study none of the above five has been directly associated with the "recreation" segments. There would still have to be a final reckoning among any conflicting interests in each segment, since there would have to be one consistent statement of its average locational desires.

In analyzing proposals for future locational patterns, the job of the analyst actually becomes one of estimating the subjective values of

men of the future. Values are not the sort of variable for which one can construct a predictive model -- there is no law of conservation of values in social systems analogous to the law of conservation of energy in physical systems. The best the analyst could do would be to select from the existing metropolitan population several groups of individuals whose interests most closely resembled those of the groups foreseen as important in the metropolis of the future.

In the past decades there has been considerable progress in techniques that can be used by social researchers in seeking out human values. One of the most useful of these techniques for this inquiry into accessibility values would be the "indifference questionnaire". This would begin by defining some standard of value for some standard condition, such as for example the condition of having one's home exactly 10 minutes from every important destination segment. Variations from this standard condition could gradually be made and the value of each variation constantly related back to the standard condition. For example, the standard condition could be modified by moving the work place 5 minutes farther away and the convenience-goods shopping center closer by some indefinite amount, all other time-separations remaining constant. The time-separation of the shopping center could be gradually varied until the person being questioned specified that the value to him of the new condition was exactly equal to the value of the former standard condition, i.e., until he was indifferent between them.[27]

By defining some similar standard condition for each of the groups being polled, the analyst could build up a whole complex of evaluations of the different combinations of time-separations that were available. It should be noted that by considering each independently in this way the analyst could no longer use merely the ordinal system of ranking values. He would have to quantify the "satisfactions" of each group in some cardinal value system; otherwise he would have no means of interrelating their different values. Ideally he should use the monetary value system, since it is a universal standard. However in the case study of Chapter 5 the evaluations are made in the fictitious units of "sats" merely to emphasize their hypothetical nature.

This same approach to evaluating proposed public programs is incorporated in the familiar "benefits versus costs" type of analysis.[28] It should be noted that these are always relative measures of how much better or how much worse off the public will be with the proposed project than at the present time without it. There need be no estimate of the total level of public satisfaction either before or after the program is completed. In the same way, the satisfactions derived from any given metropolitan plan need only be measured relative to those for alternative plans (which could include the alternative of uncontrolled growth).

The second sort of simplifying assumption recommended above, that of isolating the various realms of human values and considering them independent of each other, has been implicitly held throughout this analysis. At this point it would be best to make the explicit suggestion that the

satisfactions derived by any representative group through the provision for their accessibility needs be assumed independent of their satisfactions derived from any other realms of values, whether from the foods that they buy or the books that they read. This would also imply that the value of accessibility has no relation to the other performance indices that a community may wish to apply to a future locational proposal. In reality it is obvious that the value of accessibility to a shopping center, for example, will depend a great deal on how well that center performs its internal functions. Nevertheless the study of these interrelationships would best be postponed until the value of accessibility itself is better understood. This isolation of the different realms of value makes use of a cardinal value system mandatory if one is ever to compare the total investments and returns among the several different realms of values.

Accessibility in Terms of Alternative Combinations

Even evaluating the accessibility index alone, independent of any other aspect of a metropolitan plan, is a multi-dimensional problem. For every origin segment one might have to measure the time-separation of every other destination segment in the metropolis, pending some of the further simplifications suggested later in this chapter. The evaluation would be even more complex if one attempted to consider the variations in time-separation with the varying congestion of the circulation system at different times of day. Thus it will be almost imperative for the analyst to consider time-separation as a discrete variable that can take on only a limited number of values.

An analogy between time-separation indices and spatial dimensions should substantiate this point. If there were n different time-separations to be considered, one could chart the variations in each of these along one of the axes in an n-dimensional space. Now in order to evaluate continuous variations along every axis one would in effect have to place some specific value on the condition represented by any and every point in that n-dimensional space. This would place severe limitations on the magnitude of the number n ; even with n limited to 3, representing a cubic space, a vast number of separate point-evaluations would be needed.

A far greater number of variables could be considered if each of them were limited to a number of discrete values representing different sectors in its total range. If the number of these sectors for each variable were Z, this would have the effect of dividing up the analogous n-dimensional space into Z^n separate sectors, each of which could now be associated with a single value.

Assuming that Z represents the number of discrete values that might be taken by any given time-separation, there would in effect be Z different zones of accessibility relating to each origin segment into which a given destination segment might fall. The zones would be more or less concentric around the origin segment, with a detailed form that depended on the particular structure of the circulation system. There is some evidence that people do indeed conceive of accessibility in a series of zones -- that all trips of the same order of magnitude are considered

roughly equivalent, with a distinction between that and the next longer order of trips at some vaguely defined breaking point.[29] Though it may be a gross generality to claim that this holds for every kind of trip, this is still quite a refinement on the usual concept of a "market area" for employees or customers delineated by only a single boundary.[30]

By assuming that time-separation is a discrete variable, the index of accessibility of any given segment can be described as a combination of time-separations, one for each destination segment. The combination for each segment would probably vary from one locational proposal to the next. The problem of the analyst would now be to find the value placed by the community on each combination relative to each possible alternative combination for that given segment. It should also be useful for the designer to formulate the optimum combination for each segment and to attempt to balance it against the conflicting optima for every other segment. For example he might conceive of a balance among the desires of the merchants of every commercial segment to have themselves in the first zone of accessibility from every residential segment and all their competitors in the farthest zone.

Reducing the Number of Evaluations

To simplify the general problem of evaluation, the analyst would want to minimize the number of separate combinations of accessibility for any given segment that he might have to evaluate. He might first assume that the total value to the community of the combination of accessibility

that a plan provided for any one segment was independent of the combination it provided for any other segment. This would mean neglecting many of the variations in accessibility values, such as the effects on the value of having one's home close to a shopping center that depend upon how close one's work is to the central business district. However these effects are probably not important enough to warrant considering the interrelationships of the separate accessibility indices in the first analysis, which would have meant evaluating combinations of combinations.

Next the analyst could assume that not all of the activity-segments that make up the given metropolis are unique but rather fall into a limited number of homogeneous categories of activity. This implies the same kind of homogeneity among activity-segments that the definition of the segments themselves implied among individual establishments. In other words, this extends the size of the groups of establishments that are considered homogeneous, with one major qualification: although all the establishments in any one category are now considered uniform, they are not all bound together into a single localized complex. The indivisible unit of land use is still the activity-segment.

Any significant differences between the defined properties of activity-segments -- whether in concentration of participants within the segment, in their linkage desires, in its physical form, or in all three of these -- might involve a corresponding change in the value to the community of the various possible accessibility indices for these segments.

Any such variations could only be expressed by defining separate categories of activity. Thus there would have to be much greater sensitivity in the definition of categories of activities, and a correspondingly greater number of different categories, than in the typical urban land use analysis. For example, there would have to be several different categories of industrial, residential or commercial activity, with variations between them in concentration of participants, in land area, floorspace, capacity for participants or for material output, or any other significant dimension.

Uniformity among the activity-segments of each category would imply not only equal desires for linkage as origin-segments but also equal ability to satisfy linkage desires of others as destination segments. This would lead to a great reduction in the number of combinations of accessibility that might have to be separately evaluated, a reduction that will of course become larger as the categories of activity become fewer, more generalized, and thus less accurate.[31]

The reduction would become even greater if the analyst could assume that the value of accessibility to any one of these categories of activity were independent of the level of the accessibility to any other category of activity. However this would imply neglecting such important interrelationships as the dependence of the value of access from home to an entertainment section upon the access to other kinds of focal activity areas. This would probably be going too far in the simplifications; this assumption has been made in the case study of Chapter 5 only because the

study is intended to be illustrative rather than accurate.

There is still another sort of simplifying assumption that should be quite valid. The concern for the accessibility of any given origin segment probably does not extend to every one of the activity-segments in each category of activity but only to some limited number of the closest of them. This number might vary both with the category of activity of the origin segment and with the category of the destination being considered. Thus the concern for access to industry from residential segments might extend to nearly every separate industrial segment. On the other hand the importance of access to recreation from the industrial segments would probably extend only to the single closest park area, if its facilities were adequate.

This number of significant destination segments might actually vary somewhat with the particular combination of time-separations in each given case. For instance, whether or not the value of the separation from one's home of the third-closest grocery store were significant might depend on how far away the closest one was. However at the risk of making a few needless measurements of time-separations in some of the cases, this sort of variation can be neglected.

The effect of this assumption that the only significant accessibilities are those of the closest few segments in each category of activity is to limit the size of each of the combinations of time-separations that must be evaluated. This would place a definite limit on the total number of different combinations that could possibly occur for any given origin

segment relative to any given category of activity. This limit would hold no matter how many different plans might be considered. Its magnitude could be more clearly expressed symbolically. If Z represents the number of possible zones of time-separation, and ${}_iN_j$ represents the significant number of closest destination segments of category j to an origin segment of category i, then the total possible number of combinations of time-separation that might ever have to be evaluated for this kind of accessibility would be $Z^{({}_iN_j)}$. This is completely analogous to the formula for the number of sectors in an n-dimensional space that was mentioned on page 39.

Especially if either Z or ${}_iN_j$ are large, it is quite unlikely that all of these possible combinations will appear in any one group of locational alternatives. Many of them might be quite ridiculous in reality, as for example the combination of time-separations from one convenience-goods shopping segment to the others of its kind that would place them all in its first zone of accessibility. However it might prove to be useful that the magnitude of this quantity $Z^{({}_iN_j)}$ depends not on the total number of activity-segments in any given metropolis but only on the categories of the activities involved in the interaction and the number of time-zones that are used. If there proved to be several typical sorts of activity-segments that appeared in many different metropolitan areas, the assumptions of this chapter would allow one to study them as abstract types, independent of the nature of their particular locations. This might possibly lead to a general formulation of an optimum

combination of accessibility for each of these types that could serve as a starting point for evaluations of accessibility needs in the specific metropolises.

In this chapter four different kinds of limitations have been suggested to simplify the evaluations of the performance index of accessibility: a limited number of representative groups whose evaluations can be considered, a limited number of possible discrete zones of time-separation, a limited number of categories of activities, and a limited number of each kind of destination segment whose accessibility is significant to a given origin segment. In any operational use of this index, a balance would have to be struck between the tightness of these limits and the accuracy of evaluation desired. To keep the case study of the following chapter brief and illustrative, these limits have been set so tight that almost all meaning has been wrung from the accessibility index prior to its final evaluation.

Chapter 5

A HYPOTHETICAL CASE STUDY

The performance index of accessibility has been seen to involve a great many variations. Several different ways of simplifying them have been suggested at different stages of this thesis. The hypothetical case study of this chapter is an attempt to draw all of these different suggestions together by applying them to a single metropolitan problem.

If the objective were to actually test the validity of this operational definition, it would be best to attempt to correlate the proposed accessibility index in some existing situation with the corresponding human satisfactions. However the intention here is not so much to evaluate the definition as merely to illustrate the processes involved in its use. The case study has thus been directed at the problem of evaluating the future alternatives for the locational pattern of a hypothetical metropolis.

In order to emphasize the theory of this method rather than the magnitude of the difficulties in using it, the simplifying assumptions have been carried to an extreme. Each of them will be spelled out in detail as it is actually applied in the study. Even with these simplifications it would take a whole team of social researchers many months to determine what values people actually attached to the situation represented by each level of the accessibility index. This latter process has been completely bypassed in this case study by merely filling out the evaluations according to the author's hunches. Thus the question to be asked during the course

of this case study is not whether the answers are right but whether this process could usefully be applied in a real metropolitan planning problem.

Posing the Locational Problem

It was desired to have the case study involve a specific metropolitan context that was both small in scale and of a generally familiar nature. Therefore the data outlined below has been constructed as if it related to a typical midwestern metropolis with a population of 100,000 persons. The metropolis is thought of as the market center for a symmetrical hinterland, with the four highways from its hinterland converging at right angles upon the central business district. The site is assumed completely flat, with no topographic influences on the locational pattern.

The planners for the metropolis are considered to have complete freedom in selecting the possible future locational patterns, given only the location of the four highways and of the central business district. They are thus free to define a series of idealized activity-segments subject only to the requirements that the segments remain constant elements in all of the locational patterns which might be proposed.

The only data needed by the analyst to actually describe these segments as elements in the metropolitan pattern of activities would be the number of participants in each of them and their desires for interaction with each of the other segments.[32] However in this analysis it is desired to minimize the effects of values related to any other performance index besides accessibility. Thus the complete internal physical

structure of each segment, including the total land area that it consumes, is also assumed constant in the three future locational alternatives.

Ideally the properties that relate both to the activities and to the material structure of each segment should be carefully forecast for the future date. Account should be taken of the probable sizes of the different activity complexes for that future date, whether the residential communities or industrial estates, and the nature of the facilities that each of them would probably be using. However since the form of the individual segments is not the direct concern of this study, the segments have been defined according to the patterns of land use that appear in the existing metropolis.

The properties of the activity-segments selected to represent this midwestern metropolis of 100,000 are listed below in Table I. Their size is also represented graphically on page 53 in conjunction with the diagrams of the three alternative plans. The segments defined here are such gross stereotypes that they hardly touch upon many of the really important issues in metropolitan locational patterns. For instance it would have been interesting to study the values related to the decentralization of a few individual office buildings; these have here been lumped in with all of the central retail, wholesale and institutional facilities of the central business district. Nevertheless this sort of detailed inquiry could be carried out with this same operational definition of accessibility merely by specifying a finer scale of segments in the category of activity one wished to study. A comprehensive evaluation has been the goal in this

case study, even if the details must for the time being be neglected.

TABLE I

Inventory of activity-segments
for the hypothetical metropolis.

Category of Activity	No. of Segments	Land Area (acres)		Number of Residents		Number Employed	
		Per Segment	Total	Per Segment	Total	Per Segment	Total
Central Business	1	320	320	-	-	20,000	20,000
Convenience Shopping	4	20	80	-	-	500	2,000
Intensive Residence	4	160	640	2,500	10,000	-	-
Extensive Residence	12	720	8640	7,500	90,000	-	-
Recreation	4	320	1280	-	-	-	-
Intensive Industry	4	120	480	-	-	3,000	12,000
Extensive Industry	4	160	640	-	-	2,000	8,000
TOTALS	33		12,080		100,000		42,000

The estimates of the land areas were made by examination of land use maps for two similar existing metropolitan areas, with an attempt to keep the residential densities reasonable.[33] The estimates of the number of workers in each segment are based merely on guesses of the employment

characteristics in a metropolis of this sort.

There has been an attempt to minimize the effects of the particular design of the circulation system in order to bring out the effects of the locational patterns of the activity areas. Therefore it has been assumed that a uniform right-angled grid of streets, parallel to the major highways, covers the entire developed area of the metropolis. Enough land has been allocated to each activity-segment to include its share of the street system, along with the parking areas that might be required. Railroad locations have been neglected completely; they usually depend upon special topographic or historical patterns that will only bias the normal balance of locational interrelationships.[34]

These four basic kinds of activity-areas--commercial, residential, recreational and industrial--seemed to give a fairly comprehensive general picture of the metropolitan structure.[35] Each kind of segment would of course include a whole complex of activities--for example the land allocated to the residential segments is calculated to include schools, playgrounds and neighborhood stores. The central business segment would naturally be the most complex, involving a great many overlapping functions.

In reality each of these segments could be expected to contain a far greater diversity of functions than is accounted for here. This case study is neglecting, for example, both the residents who might be found in the central business district and the employees of institutions that might be found in the intensive residential districts. The reader may have noted in fact that the residents and employees listed in Table I

are only two of the many different groups that may have an interest in the location of any given activity segment. Of the many more groups that should be included only three are comprehended in this case study, bringing the total to the five that are listed in Table II below.

TABLE II

Functional groups considered as participants in each kind of activity-segment, listed according to the symbolic representation for each group.*

Category of Activity-segment	Symbol	Residents (R)	Customers (C)	Merchants (M)	Workers (W)	Employers (E)
Central Business	C	None	C_c	M_c	W_c	E_c
Convenience Shopping	S	None	C_s	M_s	W_s	None
Intensive Residence	A	R_a	None	None	None	None
Extensive Residence	B	R_b	None	None	None	None
Intensive Industry	X	None	None	None	W_x	E_x
Extensive Industry	Y	None	None	None	W_y	E_y

*It is assumed that there are no participants directly oriented to the "recreation" segments.

The roles which each of these five groups are assumed to play relative to each kind of activity segment will become more apparent as

their evaluations on the accessibility index are considered later in this chapter. Meanwhile it remains to outline the three different locational patterns which are to be evaluated by the five groups of this metropolis. A diagram of each of them appears in Figure I on the following page.

Each of the plans has been made symmetrical about its center. This has had the effect of repeating each of the segment locations four times (aside from the single "central business" segment), thus reducing by a factor of four the number of separate evaluations necessary. However it has also prevented the inclusion of a number of quite interesting more random alternatives in the locational pattern. It was with this symmetry in mind that the number of segments in each category aside from "central business" was kept to 4 or a multiple thereof.

Plan I involves a strong concentration of the higher density activity-segments around the core area, with the intensity decreasing steadily until one reaches the "recreation" segments on the periphery. The right angle grid of the street system has the effect of making the outlying sectors along the four highways generally more accessible than the intervening sectors between the highways; adding to this effect is the assumption that traffic on these major highways is 50% faster than on the rest of the streets. Thus it is assumed that development would naturally stretch out along these routes. This scheme is the closest of the three to the pattern that could probably be expected in a metropolis of this size.

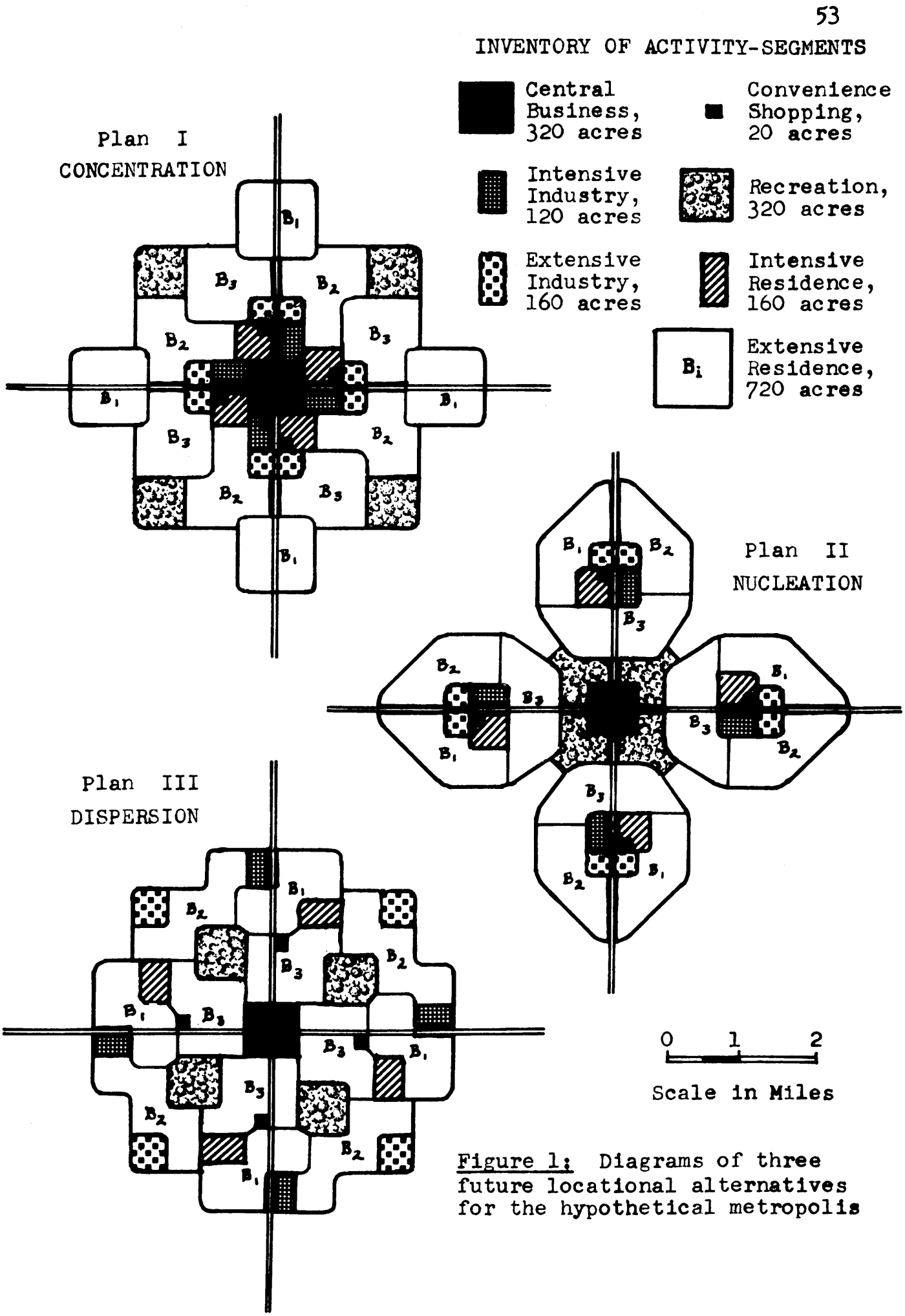


Figure 1: Diagrams of three future locational alternatives for the hypothetical metropolis

Plan II involves a nucleation of the intensive activity-segments into four very distinct clusters. The central business district has been surrounded by a park area. This is closer to the sort of locational pattern idealized by those social philosophers who would desire to see metropolitan areas reduced to a number of distinct communities each at a more human scale. Actually this sort of scheme would make more sense for much larger metropolitan areas where the nucleated units could each be larger and more diverse.[36]

Plan III involves a random dispersion of the intensive segments throughout the metropolis, with the industrial segments along the outer fringe. This would lead to what has been called a "finer grain" in the locational pattern, with more of the extensive residential areas in direct contact with the various different kinds of activity-segments. Strictly speaking none of the patterns made up of such large segments could be thought of as having a really fine grain.

Constructing and Evaluating the Accessibility Indices

Before proceeding to measure the time-separations of the segments in each of the plans, the number of the closest of each kind of destination segment that will be significant for each kind of origin segment must be established. In other words the magnitude of each of the numbers $_iN_j$ that were mentioned in the previous chapter must now be specified. These magnitudes would depend upon the desires of the individual groups who had an interest in each kind of accessibility. It is therefore necessary at

this point to make an approximate listing of the groups having a concern for the time-separations of each kind of destination activity from each kind of origin segment. This appears in Table III on the following page, along with a compromise estimate for each of the ${}_iN_j$.

Several of the patterns of interests outlined in Table III involve special hypotheses deserving further explanation. The most apparent is the suggestion that the only groups interested in the residential segments as a destination activity are the neighboring residents. The obvious demands of all of the commercial and industrial segments for access to residents have been handled indirectly in this analysis, due to the competitive nature of these demands. It would seem that the merchants and employers have more than a simple desire for access from their locations to the residences. Their concern has been considered to relate rather to the total accessibility pattern of the "residence" segments, and is expressed here as a desire for both a minimum time-separation from the residences to themselves and a maximum of separations from the residences to their competitors.

TABLE III

Probable groups having a major interest in each accessibility index, and number of time-separations that each group would consider significant in each index. (Compromise estimate of each $_iN_j$ is circled.)

Category of Destination Activity, j	Category of Origin Segment, i					
	Central Business (C)	Convenience Shopping (S)	Intensive Residence (A)	Extensive Residence (B)	Intensive Industry (X)	Extensive Industry (Y)
Central Business, total of 1	-	C_s ① W_s	R_a ① M_c (M_s) E_c (E_x) (E_y)	R_b ① M_c (M_s) E_c (E_x) (E_y)	W_x ① E_x* M_c (M_s) E_c (E_x)	W_y ① E_y* M_c (M_s) E_c (E_x)
Convenience Shopping, total of 4	C_c-1 ① W_c-1 M_c-1 M_s-4* E_c-1	C_s-1 ② M_s-3	R_a-2 ② M_s-4* (M_c)-2	R_b-2 ② M_s-4* (M_c)-2	W_x-1 ① E_x-1 M_s-4* (M_c)-1	W_y-1 ① E_y-1 M_s-4* (M_c)-1
Intensive Residence total of 4	None	None	R_a-2 ②	R_b-2 ②	None	None
Extensive Residence total of 12	None	None	R_a-3 ③	R_b-3 ③	None	None
Recreation total of 4	C_c-2 ② W_c-2 M_c-1 E_c-1	C_s-2 ② W_s-2 M_s-1	R_a-2 ②	R_b-2 ②	W_x-2 ② E_x-1	W_y-2 ② E_y-1
Intensive Industry, total of 4	None	None	R_a-3 ③ E_x-4* (E_y)-2 (E_c)-2	R_b-3 ③ E_x-4* (E_y)-2 (E_c)-2	E_x-3* ② (E_y)-2 (E_c)-2	E_x-4* ② (E_y)-2 (E_c)-2

continued on next page ...

TABLE III. (Continued from previous page.)

j	(C)	(S)	(A)	(B)	(X)	(Y)
Extensive Industry, total of 4	None	None	R_a-3 (3) E_y-4* (E_x)-2 (E_c)-2	R_b-3 (3) E_y-4* (E_x)-2 (E_c)-2	E_y-4* (2) (E_x)-2 (E_c)-2	E_y-3* (2) (E_x)-2 (E_c)-2

( ) - indicates interested groups not participating in the interaction.
* - indicates valuation depending on particular identity of evaluator within each group, neglected in this analysis.

In this simplified case study only two groups of competitors have been considered, the first consisting of all the merchants in the metropolis and the second consisting of all the employers in the metropolis. Their competiton expresses itself in two different kinds of desires concerning these accessibility indices. First, there is a desire on the part of each competing segment to have the source of its participants close to itself but far from its competitors. This sort of desire has been mentioned above, but it extends to many other kinds of accessibility. It is the reason for suggesting that the merchants are interested in the pattern of accessibility to all commercial areas from each of the residence segments, from each of the industry segments, and from each of the other commercial segments. It is also the reason for suggesting that the employers are interested in the pattern of accessibility to all of the employment areas from each of the residence segments and each of the industry segments. (This latter concern for accessibility from industry to industry is thought of as resulting from a competition for operational linkages rather than for

workers.) The parentheses in Table III indicate groups having an interest in each accessibility index only indirectly as competitors.

The second kind of competitive desire arises from the value of having one's site accessible to other desirable areas merely as a service to one's clients. The obvious example is the desire of all of the merchants and employers for access to a recreation segment. Also falling in this category are the desires of both merchants and employers for access to each kind of commercial area. Though it might be true that each merchant and employer also wished his competitors' levels of service to be low, such a petty sort of desire could not be considered by the analyst as part of the interests of the community.

So far the discussion has centered on desires of competing firms. Table III also outlines the groups having direct accessibility desires as participants in each segment. It should be remembered here that each person in the metropolis probably will participate daily in more than one of these five groups. The desires relating to the home-to-work journey have been listed here as concerns of the residents, and the table avoids the duplication of listing them also as concerns of the workers. Many of the more minor accessibility desires have been neglected, for example the possible desires of workers to be close to other "residence" segments in order to visit their friends on the way home from work. If the number of groups considered in this analysis were to be expanded, a good deal of research effort would be needed to resolve the details of these direct accessibility desires.

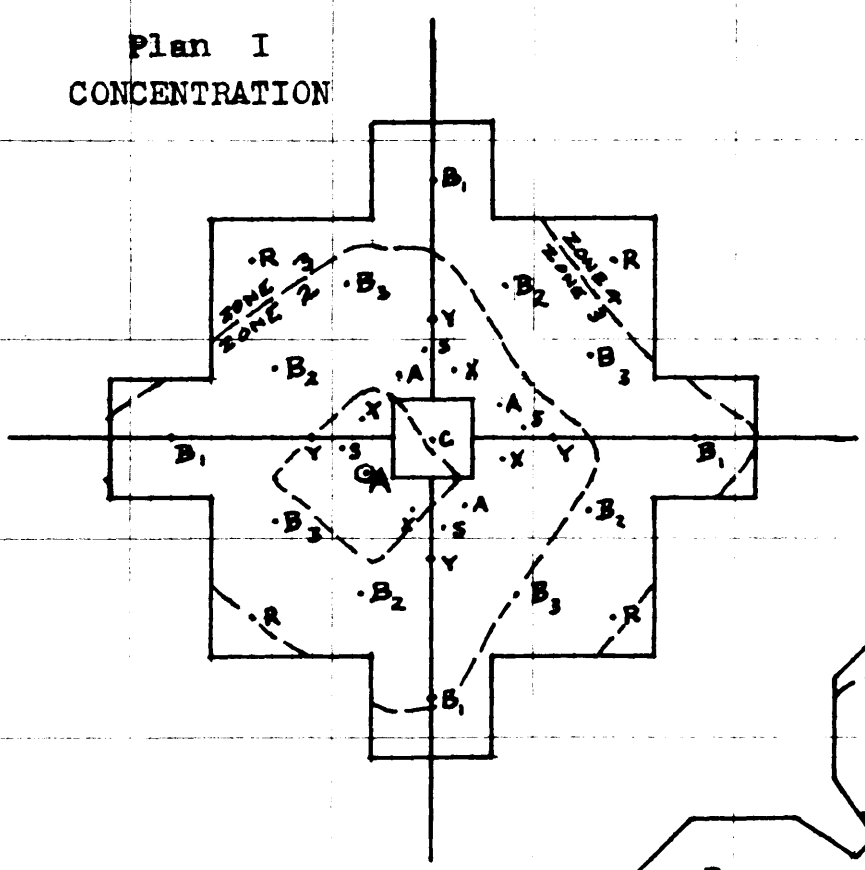
Once the individual $_iN_j$ have been determined, the analyst can proceed directly to the measurement of this significant number of time-separations in each of the alternative plans. The measurements have been made between the "centers of gravity" of the origin and destination segments; these are plotted for each of the plans in Figure 2 on the following page. (It is interesting that merely the spatial pattern of these points gives a feeling for each of the plans.) Only the automobile has been considered as the means of transportation between activity-segments;[37] this assumption could easily be modified if one had more detailed information on the probable movements in the circulation system of each plan.

The assumption of a right-angled grid street system throughout the metropolis has greatly simplified the time-separation measurements. The average speed on the typical streets has been assumed to be 14 miles per hour. Traffic along the four highways is assumed to move at a 50% greater average speed, and traffic on the streets within the central business district is assumed to move 50% slower.

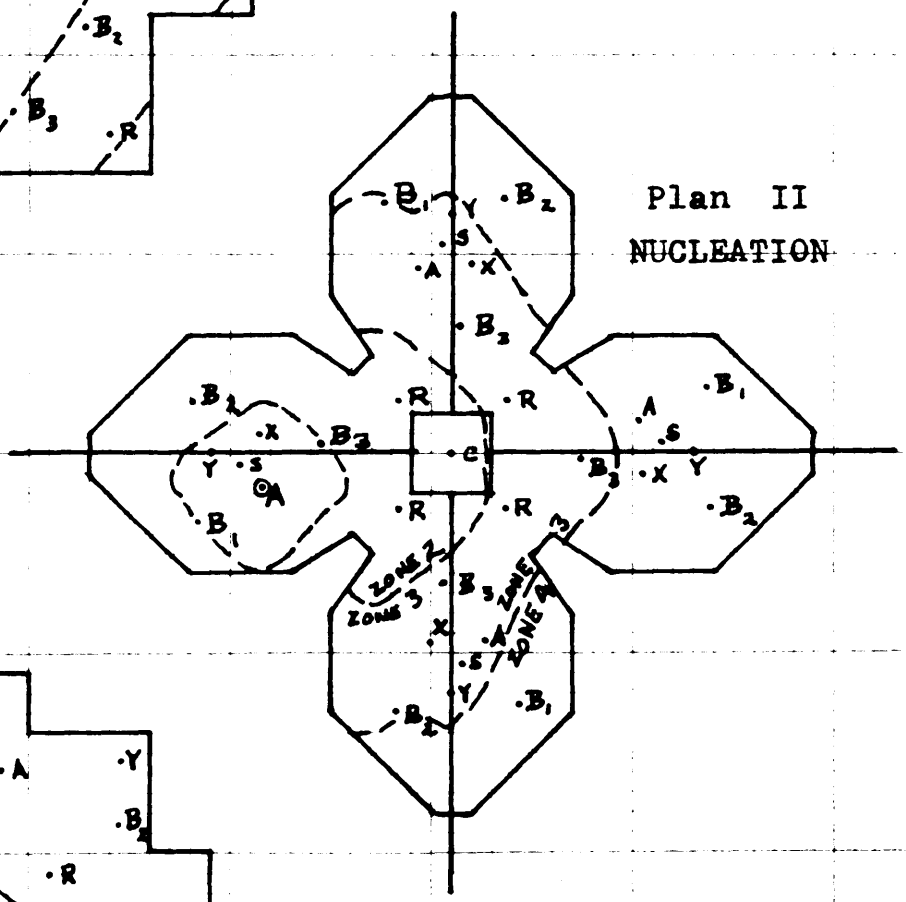
The centers of the segments in the alternative plans are plotted in Figure 2 on graph paper, so that the measurements of their separations could be carried out by merely counting the number of 1/10th-inch spaces that one would have to travel along the lines of the graph paper in each movement between segments. Along the faster highways each 1/10th-inch was counted as "2/3 of a space", and within the central business district it was counted as "1½ spaces". This process led to the combinations of separations in "number of spaces" that are listed on the following pages in Table V.

Plan I
CONCENTRATION

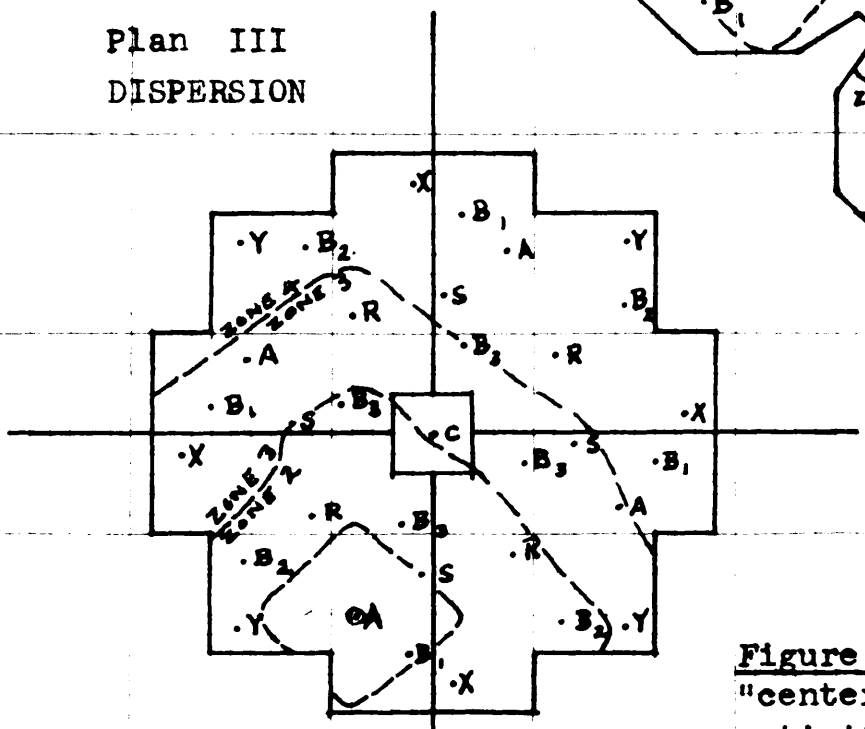
Dashed lines indicate boundaries of zones of time-separation, with intensive residence (A) as the origin segment.



Plan II
NUCLEATION



Plan III
DISPERSION



Scale in Miles

(Each 1/10th-in. square equals 20 acres.)

Figure 2: Locations of the "centers of gravity" of the activity-segments in each plan

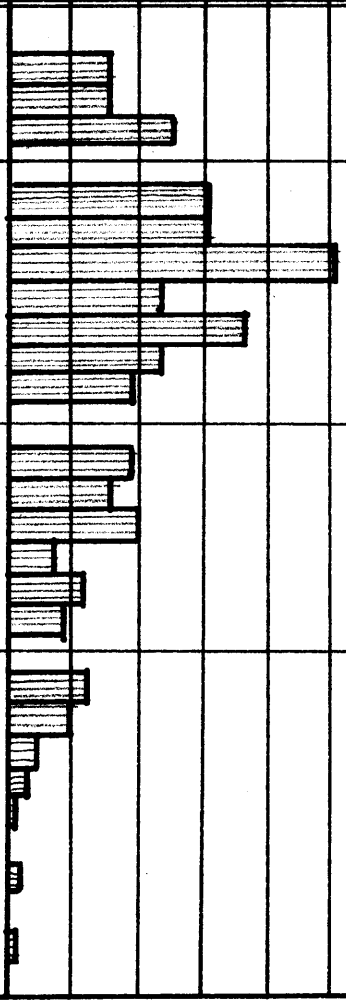
It was felt that the grouping of these separation measurements into zones of time-separation should be made according to whatever clustering of the measurements into dominant groups actually appeared in the data. With this purpose in mind a quick count was made of how frequently each separation measurement appears in Table V. Separations to the closest destination in each category were weighted double. This led to the frequency diagram for the separations that is included in Table IV below.

The equivalent number of minutes of separation for each measurement was calculated prior to the delineating of the zones of separation, as indicated in Table IV.[38] Included in each time-separation measurement is an extra 4 minutes for the terminal-time spent in loading and unloading the vehicle, parking, etc. The effect of this latter factor is proportionately much greater for the lower levels of time separation.

Personal estimates of time duration are normally made in intervals of 5 minutes. Since the data actually showed a real clustering around the 10-minute time-separation, along with somewhat of a clustering at 15 minutes, these even 5-minute intervals were used as the central points of each of the four time-zones. To give a graphic idea of the extent of each of these zones, their boundaries as related to one of the "intensive residence" ("A") segments in each of the three schemes have been sketched in Figure 2.

TABLE IV

Grouping of separation measurements into zones, according to the frequency of each measurement in the data.

Separation in Number of "Spaces"	Frequency* of Occurrence	Histogram 10 20 30 40 50	Separation in Minutes**	Zone of Time-Separation
1	0		-	1
2	16		} 6	6 to 7 min.
3	16			
4	26		7	
5	31		8	2
6	31		} 9	
7	51			
8	24		10	
9	37		11	8 to 12 min.
10	24		} 12	
11	19			
12	19		13	3
13	16		14	
14	20		} 15	13 to 17 min.
15	7			
16	12		16	
17	9		17	
18	13		} 18	4
19	10			
20	5		19	
21	3		20	
22	1			18 to 24 min.
23	0		} 21	
24	2		22	
-	-		-	
27	1		24	

* Separation of closest destination in each category of activity counted double.

** Rounded to the nearest minute. Includes 4 minutes for terminal time for each trip.

Based upon this definition of zones of time-separation, the data of Table V has been interpreted as a series of combinations of zones of accessibility, or "accessibility indices". These combinations are the factors that must now be directly evaluated by each of the interested groups. The evaluations that have been invented for each of these groups are included in the same table. If they had been the result of a carefully conducted polling of each of the groups, their summation would have represented the total value placed by the community on the accessibility provided by each of the alternative plans.

TABLE V

Hypothetical evaluation of each accessibility index by each interested group

Key to symbols used in table headings:

$_iN_j$ - Number of significant time-separation measurements
G - Groups evaluating each measurement (see Table II)
S - Number of "spaces"
Z - Zones of time-separation

CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS								EVALUATIONS (in "Sats")			
		Plan Number								Plan Number		
	$_iN_j$	I		II		III			G	I	II	III
		S	Z	S	Z	S	Z					
CENTRAL BUSINESS AS THE ORIGIN SEGMENT (C)												
Convenience Shopping (S)	1	5	2	9	2	7	2		C_c W_c M_c M_s E_c	-	-	-
Recreation (R)	2	17 17	3 3	6 6	1 1	10 10	2 2		C_c W_c M_c E_c	0 0 0 0	120 100 60 40	40 40 10 5
								TOTAL		0	320	95
CONVENIENCE SHOPPING AS THE ORIGIN SEGMENT (S)												
Central Business (C)	1	5	2	9	2	7	2		C_S W_s	[illegible]	[illegible]	[illegible]
Convenience Shopping (S)	2	9 9	2 2	17 17	3 3	12 12	3 3		C_s M_{ss}	0 0	10 5	10 5
Recreation (R)	2	13 13	3 3	9 9	2 2	5 8	2 2		C_s W_s M_s	0 0 0	10 5 5	10 5 5
								TOTAL		0	35	35

TABLE V (Cont.)

Hypothetical evaluation of each accessibility index by each interested group

(See page 64 for key to symbols used in table heading)

INTENSIVE RESIDENCE (A) AS THE ORIGIN SEGMENT											
CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS							EVALUATIONS (in "sats")			
	$_iN_j$	Plan Number						G	Plan Number		
		I		II		III			I	II	III
		S	Z	S	Z	S	Z				
Central Business (c)	1	5	2	9	2	11	2	R_a M_c (M_s) E_c (E_x) (E_y)	-	-	-
Convenience Shopping (S)	2	2 6	1 2	2 13	1 3	5 13	2 3	R_a M_s (M_c)	20 5 0	15 10 0	0 0 5
Intensive Residence (A)	2	6 6	2 2	18 18	4 4	16 16	3 3	R_a	8	0	5
Extensive Residence (B)	3	6 7 9	2 2 2	4 4 9	1 1 2	4 6 8	1 2 2	R_a	0	15	10
Recreation (R)	2	12 15	3 3	7 11	2 2	7 9	2 2	R_a	0	10	10
Intensive Industry (X)	3	3 4 8	1 1 2	3 14 17	1 3 3	7 16 21	2 3 4	R_a E_x (E_y) (E_c)	60 15 0 0	10 30 5 5	0 0 10 10
Extensive Industry (Y)	3	4 6 10	1 2 2	4 16 18	1 3 4	7 14 24	2 3 4	R_a E_y (E_x) (E_c)	40 15 0 0	10 20 0 0	0 0 5 5
								TOTAL	163	130	60

TABLE V (Cont.)

Hypothetical evaluation of each accessibility index by each interested group

(See page 64 for key to symbols used in table heading)

EXTENSIVE RESIDENCE AS THE ORIGIN SEGMENT (B) (Plan Number I Only)											
CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS							EVALUATIONS (in "sats")			
		Origin Number							Origin Number		
	iN_j	E_1		E_2		E_3		G	E_1	E_2	E_3
		S	Z	S	Z	S	Z				
Central Business (C)	1	10	2	11	2	10	2	R_b	200	200	200
								M_c	100	100	100
								(M_s)	0	0	0
								E_c	100	100	100
								(E_x)	0	0	0
								(E_y)	0	0	0
Convenience Shopping (S)	2	7	2	6	2	7	2	R_b	10	20	20
		14	3	8	2	9	2	M_s	10	0	0
								(M_c)	15	10	10
Intensive Residence (A)	2	9	2	6	2	7	2	R_b	20	20	20
		11	2	9	2	10	2				
Extensive Residence (B)	3	7	2	7	2	7	2	R_b	0	10	10
		8	2	8	2	8	2				
		14	3	8	2	8	2				
Recreation (R)	2	12	3	7	2	6	2	R_b	0	20	20
		12	3	13	3	14	3				
Intensive Industry (X)	3	7	2	7	2	7	2	R_b	60	100	100
		12	3	9	2	8	2	E_x	10	0	0
		14	3	12	3	14	3	(E_y)	15	10	10
								(E_c)	15	10	10
Extensive Industry (Y)	3	5	2	5	2	6	2	R_b	60	80	80
		14	3	11	2	10	2	E_y	20	10	10
		14	3	14	3	15	3	(E_x)	10	5	5
								(E_c)	10	5	5
TOTAL									655	700	700

TABLE V (Cont.)

Hypothetical evaluation of each accessibility index by each interested group

(See page 64 for key to symbols used in table heading)

EXTENSIVE RESIDENCE (B) AS THE ORIGIN SEGMENT (Plan Number II Only)												
CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS							EVALUATIONS (in "sats")				
	$_iN_j$	Origin Number						G	Origin Number		
		B_1		B_2		B_3			B_1	B_2	B_3
		S	Z	S	Z	S	Z				
Central Business (C)	1	14	3	13	3	6	2	R_B	150	150	200
								M_c	50	50	100
								(M_s)	10	10	0
								E_c	50	50	100
								(E_x)	10	10	0
								(E_x)	10	10	0
Convenience Shopping (S)	2	4	1	5	2	3	1	R_b	40	0	50
		18	4	19	4	13	3	M_s	60	20	50
								(M_c)	0	20	0
Intensive Residence (A)	2	4	1	6	2	4	1	R_b	5	0	10
		19	4	18	4	12	3				
Extensive Residence (B)	3	6	2	6	2	7	2	R_b	0	0	10
		8	2	7	2	8	2				
		15	3	15	3	11	2				
Recreation (R)	2	10	2	10	2	5	2	R_b	20	20	30
		12	3	12	3	5	2				
Intensive Industry (X)	3	7	2	5	2	3	1	R_b	0	0	70
		18	4	18	4	14	3	E_x	60	60	70
		20	4	18	4	14	3	(E_y)	10	10	0
								(E_c)	10	10	0
Extensive Industry (Y)	3	4	1	4	1	4	1	R_b	10	10	60
		19	4	18	4	14	3	E_y	60	60	40
		21	4	21	4	14	3	(E_x)	0	0	0
								(E_c)	0	0	0
							TOTAL		555	490	790

TABLE V (Cont.)

Hypothetical evaluation of each accessibility index by each interested group

(See page 64 for key to symbols used in table heading)

EXTENSIVE RESIDENCE (B) AS THE ORIGIN SEGMENT (Plan Number III Only)											
CATEGORY OF DESTINATION SEGMENTS	SEPARATIONS							EVALUATIONS (in "sats")			
	iN_j	Origin Number						G	Origin Number		
		B_1		B_2		B_3			B_1	B_2	B_3
		S	Z	S	Z	S	Z				
Central Business (C)	1	10	2	14	4	6	2	R_b	200	0	200
								M_c	100	0	100
								(M_s)	0	20	0
								E_c	100	0	100
								(E_x)	0	20	0
								(E_y)	0	20	0
Convenience Shopping (S)	2	5	2	8	2	3	1	R_b	10	20	60
		16	3	9	2	8	2	M_s	10	0	40
								(M_c)	15	10	0
Intensive Residence (A)	2	4	1	8	2	6	2	R_b	10	20	20
		15	3	10	2	11	2				
Extensive Residence (B)	3	7	2	9	2	7	2	R_b	0	0	10
		9	2	9	2	8	2				
		13	3	12	3	8	2				
Recreation (R)	2	9	2	5	2	5	2	R_b	30	20	30
		11	2	14	3	7	2				
Intensive Industry (X)	3	4	1	9	2	8	2	R_b	10	30	60
		19	4	15	3	13	3	E_x	80	40	10
		19	4	24	4	16	3	(E_y)	0	20	15
								(E_c)	0	20	15
Extensive Industry (Y)	3	9	2	3	1	12	3	R_b	40	20	0
		12	3	16	3	15	3	E_y	30	50	0
		27	4	22	4	20	4	(E_x)	5	0	20
								(E_c)	5	0	20
TOTAL									645	310	700

TABLE V (Cont.)

Hypothetical evaluations of each accessibility index by each interested group

(See page 64 for key to symbols used in table heading)

INTENSIVE INDUSTRY (X) AS THE ORIGIN SEGMENT											
CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS							EVALUATIONS (in "sats")			
		Plan Number							Plan Number		
	iN_j	I		II		III		G	I	II	III
		S	Z	S	Z	S	Z				
Central Business (C)	1	5	2	10	2	12	3	W_x E_x M_c (M_s) E_{cc} (E_y)	80 60 70 0 20 0	80 60 70 0 20 0	0 0 0 10 0 5
Convenience Shopping (S)	1	2	1	2	1	5	2	W_x E_x M_s (M_c)	40 20 20 0	40 20 20 0	0 0 0 5
Recreation (R)	2	13 14	3 3	8 8	2 2	9 13	2 3	W_x E_{xx}	0 0	20 10	10 5
Intensive Industry (X)	2	7 7	2 2	16 16	3 3	20 20	4 4	E_x (E_y) (E_c)	40 0 0	20 3 2	0 8 7
Extensive Industry (Y)	2	3 7	1 2	3 17	1 3	11 13	2 3	E_y (E_x) (E_c)	60 0 0	40 5 5	0 10 10
TOTAL									410	415	70

TABLE V (Cont.)

Hypothetical evaluations of each accessibility index by each interested group

(See page 64 for key to symbols used in table headings)

EXTENSIVE INDUSTRY (Y) AS THE ORIGIN SEGMENT											
CATEGORY OF DESTINATION ACTIVITY	SEPARATIONS							EVALUATIONS (in "sats")			
	$i N_j$	Plan Number						G	Plan Number		
		I		II		III			I	II	III
		S	Z	S	Z	S	Z				
Central Business (C)	1	7	2	10	8	19	4	W_y E_y M_c (M_s) E_c (E_x)	120 80 100 0 30 0	120 80 100 0 30 0	0 0 00 10 0 10
Convenience Shopping (S)	1	2	1	2	1	11	2	W_y E_y M_s (M_c)	30 15 15 0	30 15 15 0	0 0 0 5
Recreation (R)	2	11 11	2 2	9 9	2 2	9 16	2 3	W_y E_y	10 5	10 5	0 0
Intensive Industry (X)	2	3 7	1 2	13 17	1 5	11 13	2 5	E_x (E_y) (E_c)	80 0 0	50 10 5	0 15 10
Extensive Industry (Y)	2	10 10	2 2	18 18	4 4	19 19	4 4	E_y (E_x) (E_c)	20 0 0	0 3 3	0 3 3
TOTAL									505	376	56

TOTALS FOR EACH CATEGORY OF DESTINATION ACTIVITY *				
Central Business		0	320	95
Convenience Shopping		0	140	140
Intensive Residence		652	520	240
Extensive Residence	B_1	2620	2220	2580
	B_2	2800	1960	1240
	B_3	2800	3160	2800
Intensive Industry		1640	1660	280
Extensive Industry		2020	1504	224
OVERALL TOTAL		12,532	11,484	7599

*Counting 4 of each kind of origin segment, except "central business".

The fictitious units of value used here are "sats". As mentioned in Chapter 4 in connection with this general sort of "benefits and costs" analysis, it does not really matter to the locational analyst how much total satisfaction the community derives from each alternative but only how great are the relative differences in satisfaction implied by the different plans. Thus to set a basis for each numerical estimate it has arbitrarily been specified that each evaluating group assigns zero "sats" to the alternative that it desires the least.

Somehow the magnitude of the "sat" must also be defined. It is arbitrarily specified here that there is a difference of 100 "sats" between the satisfaction derived by the residents of each group of four of the "extensive residence" segments from the worst combination of accessibility to the "intensive industry" segments (2-4-4) and their satisfaction derived from the best combination (2-2-3). From this definition the whole complex of sat-evaluations has been built up by estimating how the individual persons whose daily lives involve them in several different groups would compare their many different alternatives.

Table V in effect gives a three-dimensional breakdown of the community's evaluation of accessibility--according to the kind of origin-segment, the kind of destination segment, and the group making the evaluation. This table has lumped together all of the individual segments in each evaluating group, for example all of the four convenience shopping segments that each furnish part of the general "M_S" group. In any realistic analysis at least three further dimensions should be introduced,

giving first the particular identity of the destination segment within each "category of destination activity", second the particular identity of the evaluating segment within each general functional group, and third the motives for each evaluation.

The group evaluations for which the identity of the individual evaluating segment would be especially important are indicated in Table III by an asterisk. These involve competing activity-segments that each desire the sources of their clients to be accessible only to their own particular segment. For instance, the merchants of a convenience shopping segment will place quite different evaluations on a given combination of accessibility from a "residence" origin to a "convenience shopping" destination depending on where their own segment stands in this combination. Since all of the plans are symmetrical in this case study, each of the groups of merchants would find itself standing once in each of the possible positions, depending on the sector of the metropolis in which the origin segment was located. Thus the totals of the four (or twelve) evaluations by each of the segments of any competitive group would be identical. It is these totals that have been listed in Table V, but a further breakdown according to the identity of each destination and each evaluating group would have led to more accurate evaluations.

The individual evaluations could also have been broken down further according to the particular motive involved. As a first approximation one might use the six different "sources of accessibility values" listed in Chapter 3. Actually all of these were kept in mind during the invention of

the values listed here, but the hunch as to the importance of each has not been indicated.

Evaluation and Further Suggestions

The indices of accessibility that appear for each of these three alternative plans could more or less be sensed in advance by a visual examination of each of them. At least the analysis has served to make them explicit, even if only in very general zones of time-separation. A typical series of indices that might be expected of each of these plans is the one which appears under the "intensive residence" origin segments for the destinations of "extensive industry". These indices give the time zones of 1-2-2 for Plan I, 1-3-4 for Plan II, and 2-3-4 for Plan III. Plan I gives these segments a favored position, and it likewise gives quite good locations to all but the "extensive residence" and "recreation" segments. The nucleation of Plan II keeps at least one other segment of each kind close at hand, but for a selection of destinations one is forced to go quite far afield. The dispersion of Plan III appears to provide different destinations in each but the very closest zone of time-separation.

The grid circulation system with converging highways actually gives a built-in advantage to Plan I. This effect could have been offset by taking the time to design an optimum circulation system for each alternative, as long as some account could be kept of the total investment in each system. For instance, Plan III would have fared much better with a

circumferential highway just inside the industrial segments.

It has been emphasized throughout this thesis that the actual evaluations of accessibility by the metropolitan citizens must form the core of any accessibility analysis. To be realistic they should be in the standard currency of value--dollars--rather than in fictitious units such as "sats". The series of representative groups should be checked to see that it accounts comprehensively for the resources and interests of each individual and each corporate body in the metropolis. General censuses both of the individuals and of the corporations would be extremely useful in this respect.

With the limited resources of most planning analyses, actual evaluations could be obtained only from a relatively small number of individuals selected from each group. As mentioned in Chapter 3 the indifference questionnaire would probably be the most useful tool for finding the values these people might place on each accessibility index.

It might seem that when one analyzes a plan in the name of a public agency with this poll technique one is actually asking only a selected few of the citizens to vote on decisions that should be made by a democratic majority. However this is really only a tool for developing metropolitan plans rather than for judging whether these plans shall or shall not finally be accepted. Even the expression of the desires of a selected few of the metropolitan citizens is usually lacking during the process of formulating of locational plans.

Had these various evaluations of the accessibility indices accurately reflected the needs of each group, some interesting information might have been obtained by summing the evaluations in each of the several dimensions of analysis as well as for the total of the metropolis. For example, it would be worth finding the total value placed by each evaluating group on all of the indices relating to each plan. This might point up groups whose interests were being generally neglected. A total could also be found for each plan of the evaluations relating to each destination activity, indicating how well that activity was being integrated into the metropolis. If there were a breakdown of evaluations according to motive or "source", totals for each of them would give insights as to the really important sources of value in locational patterns. Finally, the totals could be obtained for the accessibility values afforded to each kind of origin segment, as has been done in Table V.

In conclusion it should be stressed that this process of making independent evaluations of separate parts of an index, merely adding them to obtain the total, can only be a technique for first approximations. In reality the value of any one part of the accessibility index may depend upon the level of any one of the other parts. This holds true not only for the separate parts of this accessibility index but also for the whole index itself as only one of the many performance tests that must be made of any proposed metropolitan plan. One could not really isolate accessibility values by assuming all other factors constant. It has been

suggested above that even the constancy of a grid street system may give special accessibility values to some particular plan. All of the interrelated performance indices must be brought into play simultaneously if the utmost in value is to be obtained from the metropolitan planning process, for the whole is far more complex than the sum of its parts.

Chapter 6

REVIEW AND REFINEMENT

The meaning of the accessibility index as it has been defined in this thesis rests on four basic concepts. Each of them is subject to a great deal of refinement beyond its form presented thus far. Each can also form the core of more specific inquiries into the validity of this general approach.

Following the review of these basic concepts are several suggestions of problem-areas in which this general sort of accessibility analysis might prove fruitful. The thesis concludes with a few thoughts as to how accessibility as defined here might form the nucleus of a general theory for the development of metropolitan locational patterns.

The Four Central Concepts

> First, that evaluation of plans by public agencies is best carried out through a series of performance indices that attempt to measure the various qualities of the plans that might have value for the citizens of the community.

Accessibility is conceived as merely a single one of the many performance indices expressing the range of desires of a community and affecting its evaluation of a locational plan. This serves to place an emphasis on human values rather than purely prediction of social behavior. The immediate objective has not been to explain present locational patterns nor to predict what future form they will take under the normal play of market forces. Instead, the thesis is based on the supposition that public agencies can

foresee what effects their conscious decisions will have upon a community's locational pattern and can evaluate them rationally.

The most needed refinement in the use of performance indices is the interrelation of their effects upon the values that each of them creates. The following section suggests ways in which the value of the accessibility index might be interrelated with the effects of the internal structure of the activity-segments, such as the amount of open playspace in residential areas or the opportunity for face-to-face contacts in the central business district. Any research leading to this sort of multiple correlation between the effects of the various performance indices, even if vague in its initial stages, would be invaluable. A very specific move in this direction was the recent study by Isard and Coughlin of the interrelationships of density of population, quality of service, and costs for providing various municipal services to a typical new residential sector attached to an existing town.[39]

> Second, that the space economy can be understood as a system of interacting activity-segments, whose significant individual properties are first, the category of dominant activity, second, the number and kinds of individual participants in the several activities, and third, the desires of these participants for interaction with other activity-segments of the metropolis.

The grouping of the individual establishments into a series of activity-segments allows the systematic expression of the metropolitan-scale space economy to be manageable. As the number of different categories of activity or the number of segments within each category is increased, the analysis becomes correspondingly more realistic but also

more complicated.

In the case study of Chapter 5 the internal structure of each activity-segment was also assumed fixed in each of the three alternative plans in order to minimize any variations other than the locational pattern. A more refined analysis would comprehend such variations in structure and test the resulting alternatives by a whole series of interrelated performance indices.

There might for example be a performance index measuring the degree to which a plan satisfied the citizens' desires for open lawns and playspace in the residential segments, and thus increasing the average time-separations from other segments, all other factors being equal. However, the analyst could not simply add the value of the open spaces to the value of accessibility to other activity-segments. Rather, the value to the residents of accessibility to at least the recreational segments would be intimately related to how well their desires for open space were provided for within their own segments.

Another such performance index might measure the degree to which the structure of the central business district provided for the desires of businessmen for face-to-face contacts. This might require extra space for both formal and informal meetings. However, this would not merely have the effect of increasing the size of the central business district and thus its average time-separation from the other segments of the metropolis. It would also increase the value that the citizens would place on any given level of accessibility to the central business district.

It appears that the structural characteristic of the activity-segments most closely related to the accessibility index is the land area that they consume. It was assumed in the case study not only that the land consumed by each segment was fixed but also that it was contiguous on the map. It might be a useful refinement to drop this assumption that each segment was the sole occupant of the region within its boundary.[40] This could be accomplished even while holding the total area of each segment constance if it were possible for two or more segments to share an intervening area without any inefficiencies in the use of space, as indicated for example in Figure 3 below.

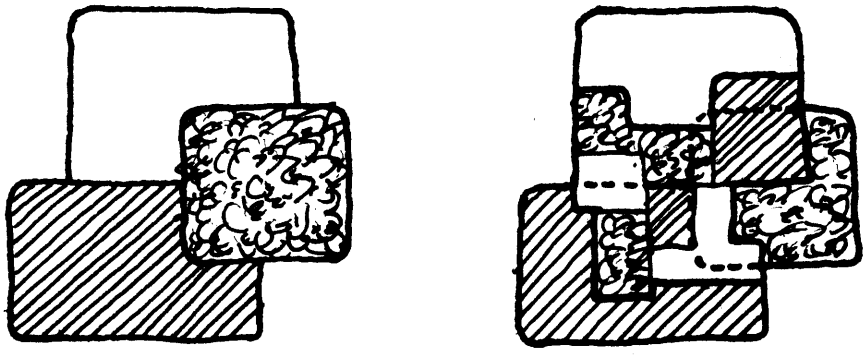


Figure 3. Possible spatial mixing of activity-segments along their boundaries, keeping the assumption of constant land area for each of them.

The chief difficulty in this process would be in accurately expressing the time-separations from a segment that was thus dispersed in space. Nevertheless measuring separations from its"center of gravity" would be reasonable as long as the outermost fringes of the segment could

be encircled by a not-too-distant boundary. This would involve no more inaccuracies than for example a measurement from the center of a completely contiguous segment whose boundary included the same amount of territory. In either case, accuracy demands keeping the size of the segments to a minimum. Since this overlapping and dispersing of activities occurs mostly among the higher density segments in the core areas that seldom extend beyond the scale of pedestrian circulation, much of it could be permitted without ill effect in a fairly gross metropolitan scale analysis.

The concept of activity-segments arose largely from the desire to simplify the model of the space economy. Before this model is applied in actual metropolitan studies, research should be undertaken to find the strength of whatever bonds actually do tie together clusters of establishments in the activity-areas of our cities.

> Third, that a good index of the accessibility of any origin segment is the combination of time-separations of the closest significant number of destination segments in each category of activity, expressed through a series of zones of time-separation.

Time of travel is felt to be the most significant of the several possible measures of separation between activity-segments. Where information is also available on other factors such as the cost of travel, the "social distances", or the physical characteristics of the route, these should be used to refine the simple time-separation into a more complex and realistic measure of the separation between each pair of activity-segments.

There has been a great deal of research effort in the past directed toward finding useful indices for describing the trips made by people within urban areas. Though time of travel has often appeared dominant in general, it would be useful to know how each of the four possible indices mentioned above varied in importance with the nature of the origin and the destination of the trip. Also, once a series of activity segments in a metropolis had been clearly defined, special research effort would be needed to find the number of each kind of destination segment that could be considered significant for each kind of origin segment.

> Fourth, that the actual evaluation of the index of each kind of accessibility provided for each origin segment should be obtained through a polling of the functional groups of persons having a major stake in that accessibility.

Since human values are in their very essence subjective, evaluations of the various performance indices can properly be made only by the individuals actually living in each of the situations to which the indices might apply. Although no one can live in situations that are merely proposals for the future, these can at least be approximated by parts of the existing environment or by hypothetical descriptions. There will probably be no group of people with values more closely resembling those of a functional group in the future metropolis than the members of the equivalent functional group existing at the present. It is up to the skill of the researchers to communicate to these people the essence of each proposal in a way that allows them to make an evaluation of it.

In the case study of Chapter 5 the index of each kind of accessibility for each origin segment was evaluated independently of the other indices calculated for that same segment. This would be a dubious procedure for any realistic analysis, since the value of any one of these indices would be closely related to the level of each of the others. Though the basic objective of the research would be finding the value attached directly to variations in each index, this expression should be further refined according to the effects of variations in other indices that might be significant.

There has been relatively little research in the past directed toward finding the values that people would place on alternative kinds of accessibility within a potentially available range. Most of the effort to date has been in the nature of ecology, measuring the existing patterns that have resulted from the interplay of these desires with the various restraints on their achievement over the preceding decades. The indifference questionnaires suggested in this thesis comprise only one of a number of techniques that might prove useful in seeking out accessibility values. To establish just which techniques might be best used in a particular metropolitan study, a good deal of prior research will be necessary.

Further Applications

From the considerations of the paragraphs above it is evident that a great deal of further research would be necessary before this definition of the accessibility index could be assured to have an operationally useful form.

Nevertheless even as it stands at this point the definition can give a feeling for some of the factors that should be weighed in formulating a metropolitan locational plan. In large measure it only makes explicit some of the dimensions with which land use planners have been always working.

This general sort of definition might prove useful in finding solutions to several other kinds of locational problems. Most locational decisions are really made by private individuals and corporations rather than public agencies. Locational theorists have long stressed the importance of accessibility in reaching these decisions. In these studies of individual accessibility needs, two of the concepts developed in this thesis might prove useful.

First, it might be helpful to include the combinations of distances from a potential site to several possible locations of each kind of "resource" or "market", rather than just to the closest one of these. This could account for possible needs for multiple destinations of the kind mentioned on page 29.

Second, a competitive firm seeking a new location would find special value in locating near sources of clients that were not presently well served by its competitors. For example, a grocery chain wishing to open a new super-market could find the index of accessibility to existing super-markets relating to each sector of the residences in the metropolis. Its optimum location would then be the one which would afford it a relatively higher index of accessibility to those residences which had a relatively lower index of

accessibility to its competitors, barring variations in factors other than accessibility.

"Comparative anatomy" studies between different metropolises are another kind of locational problem in which the definition of accessibility might prove useful. A planning agency in any one metropolis must normally consider the variations in its own structure over periods of time; studies of variations in structure from one metropolis to the next could yield valuable additional insights into the underlying forces. Such studies would have to rely on a sensitive definition of the standard "types" of activity-segments used to express the different metropolitan patterns, a requirement demanding a great deal of further research.

Locational patterns at other than a metropolitan scale could likewise be analyzed according to the way in which they provided for the accessibility needs of their users. For example, patterns of development of larger regions including many urban clusters could be studied to find those parts of the region to which each group of the population desired accessibility. In this case the individual "activity-segments" would probably consist of whole cities and towns.[41] At a less-than-metropolitan scale, the internal structure of residential neighborhoods could be studied in terms of the combinations of activities to which the residents desired access. Perhaps the architecture of an individual building could be systematically analyzed to find the accessibility it provided between the various locations within, though at this scale an unsystematic subjective analysis is usually sufficient.

A General Theory for Metropolitan Development

In the process of developing a method for evaluating locational patterns many assumptions have been made concerning the factors that might give these patterns value. If the assumptions are valid there should be some reflection of these values in the actual development of a metropolitan area. Obviously the myriad desires of the metropolitan citizenry get jumbled together as they work themselves out in the normal play of market forces. Groups will be represented in the market often more according to their financial or political power than according to the stake they have in the locational pattern.[42] Still, if it is accessibility that the different groups are seeking this systematic desire should set the general trends of development.

Metropolitan development can best be understood in terms of changes both in the activity, or the "land use", at each location and in the physical facilities that serve it. Whether or not existing activities or facilities in an area will change in the near future depends upon two major factors: first, how well they are presently providing for the needs of the metropolitan citizens (or some small group thereof) and second, how well they might provide for other sorts of needs with certain amounts of investment in a change. Both of these factors could be expressed in terms of performance indices.

The two most important of the many different performance indices that might be included would probably be the cost of adapting each location to each possible kind of activity and the combination of accessibility to

each kind of destination that each location provides. In analyzing a metropolitan area, the first step would be to classify each piece of land according to how much investment would be needed to adapt its facilities to each of the different categories of activities.[43] This is understood to include the costs of complete demolition and reconstruction if it might be necessary. Varying degrees of this capital investment should be considered, leading to varying degrees of efficiency of the facilities. Naturally the costs of adapting a piece of land to its present use would be zero, barring obsolescence.

To these "capital costs" for each activity relating to each piece of land should be added the capitalized value of the rent that the activity would have to pay. The factors that determine rent are often unsystematic and unpredictable, including at times such things as the structure of the metropolitan traffic, the aesthetic qualities of a piece of land, or perhaps its social identity. Thus the existing rent would probably have to be used in this calculation.

This would complete the cost analysis for each piece of land relative to each activity. The next step would be finding the potential benefits that could accrue to each activity through locating on each of the different pieces of land in the metropolis. As an index of these benefits one could calculate the accessibility from each piece of land to each of the categories of the destinations in the metropolis, in the way that was outlined on page 40. By basing these calculations upon time-separation between segments, one would be including the effects of

congestion in the circulation system that have often proved an obstacle to systematical locational theories. The particular index that measured the accessibility of residences from each piece of land would be roughly equivalent to "population potential" as it is currently conceived.[44]

The third kind of basic data required would be an accounting of how much each of the activities could afford to pay for each different set of accessibility indices that they might obtain at one or another of the available sites. This calculation of the resources of each activity might for households be related to family income and for business firms to the potential margin or "value added in manufacture" that could be realized with each kind of accessibility.

A fourth kind of necessary information would be the total amount of each category of activity that could be supported by the metropolis. This would not necessarily mean that growth in the total of each category had to be gradual in the near future. There might well be some activity for which the metropolitan capacity had hardly been exploited, as was witnessed in this country recently with the sudden boom in the new activity of drive-in outdoor movies.

By bringing together these four kinds of data, one could make a prediction as to locations of the likely changes in the pattern of land use in the metropolis. Change would probably occur where all of the following conditions were satisfied: (1) where the potential land user could with the given quality of accessibility afford to pay both the

rent and the costs of adapting the facilities, (2) where the amount the present user could afford to pay was not sufficiently higher than the present rent to allow him to out-bid the potential user, and (3) where the total amount of the new activity that could be supported in the metropolis was not already drawn to more attractive sites. One might make a fourth requirement that there be no sufficient irrational restraints upon the change, such as public ownership of the land or a zoning law. A dynamic sort of restraint might also be introduced by specifying how much total construction activity per unit of time could be carried on in the metropolis.

To make any predictions of developments in the metropolitan land use pattern by using this complete technique would demand a very large investment in research. For very rough predictions much of this might be bypassed by a person whose extensive experience in the particular community might give him a general feeling for the different factors involved. However to attempt to simplify the process in an abstract way by making purely geometrical generalizations, such as for instance that new industrial estates will always tend to locate a certain number of miles in a straight line from the center of the core area, would destroy most of the meaning of the complex accessibility indices.

This outline of some of the other factors that would have to be included in anything like a general theory for metropolitan development serves to emphasize that this thesis has only been seeking a method for systematic evaluations. The objective has not been to help turn the art of city planning into a scientific process. The analogy between the sort of conceptual model suggested here and a tool used by an artisan seems to be a good one. A new and better tool gives an opportunity to shape the same material into new forms that would not otherwise have been possible. Nevertheless the finished artifact, like the city plan, must still be the product of the human creative process.

NOTES TO THE TEXT

1. The idea of analyzing urban patterns through this sort of performance indices is developed more fully in the unpublished report "An Activities Approach For Understanding Metropolitan Form" by BLAB (a four-student team which included the author), M.I.T., May 1957.

2. Many of the relationships of accessibility to the total metropolitan space-economy are suggested by Lloyd Rodwin in Suggestions for Research on the Spatial Distribution of Activities . . , (Bibliography, No. 12) On page 5 Rodwin states: "Emphasis on the accessibility requirements draws attention to the spatial relationships; and it also provides a common denominator for the reinterpretation of all kinds of location studies: residential and non-residential, economic, demographic, sociological, historical, political, and other approaches. Factors such as convenience, prestige, transportation, speed, water and the like can be treated and even translated into spatial and price relationships."

3. For a mathematical expression of the concept of a system of interacting elements, see Ludwig von Bertalanffy, "An Outline of General Systems Theory" (Bibliography, No. 1). Before any of the kinds of differential equations outlined by von Bertalanffy can be applied to the space economy system, there must be some systematic expression of the "space friction" or degree of accessibility separating its elements.

4. The conceptual models of social physics usually attempt to draw an analogy between certain social and economic systems in their existing state and certain physical systems, notably those involving the disposition of particles in space. A prediction of the future state of the social or economic systems is then attempted by calculating the corresponding future state of the analogous physical system, assuming of course that the analogy will hold throughout the period of prediction. For a good summary of this approach, see John Q. Stewart, "The Development of Social Physics" (Bibliography, No. 13). Stewart gives several interesting analogies between phusical and social systems, aside from the idea that desire for interaction between activities is like gravity force between particles. For example he also suggests that rural population acts as a "gas" that tends to "liquify" as it clusters in cities; that the levels of activity of these human beings are like levels of temperature in the gas or liquid, increasing as the pressure rises toward the center of the liquid clusters; that the cultural orientation of people is like the physical orientation of polar molecules that gives a substance magnetism, becoming more difficult to maintain as the temperature rises; that population stretches out along the routes of major highways is if by capillary attraction; and that the irrational ties that bind people to particular places are like the cohesion of a substance for other particles of its kind or its adhesion to materials of a different kind.

NOTES (cont.)

5. See Ernest W. Burgess, "The Growth of the City: An Introduction to a Research Project", in R.E. Park, E.W. Burgess, and R.D. McKenzie (eds.), The City, Chicago, 1925, p. 47.

6. See Homer Hoyt, The Structure and Growth of Residential Neighborhoods in American Cities, Washington, 1939.

7. See August Lösch, The Economics of Location, New Haven, Yale University Press, 1954, pages 124-130.
Lösch proceeds to his suggestion of an ideal metropolitan pattern merely by manipulating his purely geometrical construct of a hierarchy of hexagonal market areas, without first accounting for the many variations in geometry that will depend upon such things as topography or the traditional focal organization. When he predicts an ideal number of radial highways based wholly on the six-sidedness of each market area, he is speaking more of abstract geometry than of the real world.

8. See Rodwin, op. cit. (note 2), for an exploration into many of these factors.

9. The effects of the other measurements besides time-separation will be particularly negligible for automobile owners who do not keep a strict accounting of costs. For an example of how time-separation proved the more important in a specific case study, see Richard S. Bolan, The Journey to Work in Recently Suburbanized Industry, unpublished M.C.P. thesis, M.I.T., Cambridge, 1956. Bolan states on page 33: "Time (of travel) seemed to have far more controlling or restricting effect than cost and also seemed to indicate far more regularity when plotted with the residential distributions."

10. For a more thorough outline of the meaning of "establishment" as used in this sense, see Mitchell and Rapkin, Urban Traffic . ., (Bibliography, No. 9), page 38.

11. Ibid., page 111.

12. For a very clear exposition of the relationship between linkages and land use patterns, see John Rannells, The Core of The City, (Bibliography, No. 10), pages 19-21, and pages 178-182.

13. Alderson and Sessions, Philadelphia Central District Study, Philadelphia City Planning Commission, 1954, page 24.

14. In his summarizing chapter, Rannells states: "It will require further investigation to demonstrate how fully the vital relationships among activities do relate to the proximity measures which have been used as the basis for this inquiry." op. cit., (note 12), page 170.

NOTES (cont.)

15. As an alternative to this concept of an activity-segment occupying a contiguous space, it might be possible to consider it as only a more or less localized group of facilities that might appear somewhat scattered when analyzed at a small scale. This approach would lead to real complications in the design process; it will be considered in Chapter 6 as a refinement on the accessibility analysis method.

16. Practically all of the studies of urban accessibility value to date have considered only the separation of each area from the core of the metropolis. For example, see Ernest W. Burgess, op. cit. (note 5), Donald J. Bogue, The Structure of the Metropolitan Community, Institute for Human Adjustment, University of Michigan, 1949, and Walter Isard, Location and Space Economy, (Bibliography, No. 7), pages 200-206.

17. The differences in scale between the urban and rural space economies become evident at the developing metropolitan fringe. The value of fringe land for agricultural uses falls off only gradually as distance from the edge of urban development increases; probably the distance to the core area of the metropolis is more important. However the value of the same land for urban uses has a critical relationship with accessibility not only to the core area but also to many of the other urban activity locations. The scale of values of these urban activities is so far above those of the adjacent agricultural activities that one seldom finds a farm that can resist the pressures of a determined subdivider.

18. It is possible to develop a complete theory of economics through establishing the relationships between various substitutions among the available inputs to the productive processes and the value of the resulting outputs. This substitution framework forms the theme of Walter Isard's recent book, Location and Space Economy. (Bibliography, No. 7). He states on page 281: ". . we find a general substitution framework of relevance in approaching urban land-use problems, let alone in attacking the entire range of land-use problems, wherein the competition between agricultural uses and industrial, commercial, and residential uses is encompassed as well." In these terms, the assumption of the text implies that no consideration can be given at this point to substitutions between location advantages within the metropolis (such as low transport cost for one's customers) and any of the other factors of production, ranging from factory technology to the quality of the employees.

NOTES (cont.)

19. To predict an optimum form for some given system in terms of given values, one would need to know both the total value of each form that the system might take and the marginal effect upon this total value of any possible differential change in form. This latter condition cannot be fulfilled when the system consists of a number of contiguous regions in space that each have a fixed area, and when values are related to distances between these regions. Any differential change in form would imply a complete reshuffling of the regions, which could take place in so many varied ways that the corresponding marginal change in total value would only be vaguely determined. Thus it is questionable whether August Lösch could really have succeeded in his hope to formulate a predictive model for optimum patterns of the space economy. See his Economics of Location, op. cit., (note 6), Chapter 8.

20. Robert M. Haig, "Major Economic Factors in Metropolitan Growth and Arrangement", (Bibliography, No. 6), page 39.

21. See Edward H. Chamberlin, The Theory of Monopolistic Competition, Harvard Univ. Press, 1950. Chamberlin's study is oriented around the thesis that this sort of partial monopoly appears not only through location advantages but also for any kind of good or service that is unique in any significant respect. Concerning the source of urban rents, he states on page 268: "The rent on any urban site is an expression of the value of the monopoly privilege of providing retail services at that particular place. Competition among entrepeneurs to secure these monopoly gains is the force which puts them into the hands of the landlords."

22. The relationship of the spontaneity of an interaction to the value placed on accessibility or "convenience" of that activity has been stressed by Dennis Chapman in The Home and Social Status, (Bibliography, No. 3), on page 192: "This suggests that it may be possible to divide journeys into those which are undertaken without serious preparation in the midst of other activities and those for which there is a plan and a specific time allocated. For the former, only short journeys are tolerated; for the latter, the planner has much greater freedom in locating the destination."

23. The conception of welfare economics presented in these pages has been drawn largely from I.M.D. Little, A Critique of Welfare Economics, (Bibliography, No. 8).

24. Ibid., page 49.

NOTES (cont.)

25. For example, in the treatise by Little, op. cit., page 30, it is suggested that an individual's order of preferences be expressed by a series of indifference or "behavior" lines, in effect contour lines of iso-choice in an n-dimensional "commodity space". According to Little, "'On a higher behavior line' does not entail 'more satisfaction", although it does entail 'in a chosen position'. But the fact that a man is 'on a higher behavior line' may be taken as good evidence that he may be more satisfied.

26. A simple algebraic example will show how the number of available combinations among a group of variable quantities can be greatly simplified by dividing these quantities up into a number of independent sectors. Assume that a system contains n different quantities, each of which may take on Z different values. Taking these n quantities as a whole, the number of different possible combinations of values will be Z^n. Now assume that these n quantities can be divided into p different sectors within each of which the combination of values is independent of the combinations in the other sectors. Assuming for the sake of simplicity that all of these sectors contain n/p quantities, the number of possible combinations in each sector will be $Z^{(n/p)}$. For all the sectors together, the total number of possible combinations will thus be reduced to $pZ^{(n/p)}$, which will be smaller than Z^n by an amount that depends upon the magnitude of p. For example, n equals 9, p equals 3, and Z equals 4, there will be $3x4^3$ or 192 possible combinations with the division into sectors, but 4^9 or 252,144 combinations without it.

27. The value of indifference questionnaires in determining accessibility values was suggested by Walter Isard, to whom the author is especially grateful for a whole series of criticisms and suggestions. In effect, these questionnaires would be seeking to establish the "behavior lines" or the lines of "iso-choice" for accessibility, of the sort that were mentioned in note 25 above.

28. In quantifying these evaluations, a benefit can be expressed as a negative cost, and vice versa; the analyst must still decide, arbitrarily, which direction will be considered positive. In the sample estimates of the case study benefits are considered as positive values and costs as negative valyes, leading to positive numbers in the direction of increasing satisfaction.

29. For example, to quote from the study by Denis Chapman, op. cit. (note 22), page 185:

"The analyses of journeys by time show a clearer picture and help to account for the differences found in the analyses by distance. . . . The evidence shows that inconvenience becomes important after 22 minutes. A further analysis has been made to indicate the threshold effect."

NOTES (cont.)

This study considered the needs and desires of residents in workingmen's towns in England and Scotland. Nevertheless the indication of the habit of judging time-separation by zones relates to a general sort of human trait.

30. For an outline of the theory and implications of the study of market areas in terms of boundaries, see Edgar M. Hoover, Jr., Location Theory and the Shoe and Leather Industries, Cambeidge, Mass., Harvard University Press, 1937, Chapters 2 and 3. For an application of these concepts to metropolitan labor markets, see William Goldner, "Spatial and Locational Aspedts of Metropolitan Labor Markets", American Economic Review, March 1955, pages 113-128.

31. For an idea of the magnitude of this reduction in the number of combinations to be evaluated, one should refer to the calculations in note 26 above. If n represented the total number of activity-segments in the metropolis, Z represented the number of discrete zones of time-separation, and p represented the number of categories of activity-segments, then the formula $pZ^{(n/p)}$ would represent the possible number of combinations of time-separations from any one origin segment. However the formula would be this simple only if one continued to assume that each of the categories contained exactly n/p segments.

32. The systems analysis utilized in this thesis relates to patterns of activities rather than patterns of material forms. See pages 9 and 10.

33. To give some empirical basis for these very generalized activity-segment definitions, reference was made to statistics and maps of existing land use in the urban areas of Lincoln, Neb. (population 104,000), and Sioux Falls, S.D. (population 55,000), as published in Bartholomew, Harland, Land Uses in American Cities, Harvard University Press, Cambridge, 1955, pages 30, 42, 50, 60, 133, and 181-185.

34. Access to rail facilities will be a necessity for many of the functions of the industrial and central business segments. With this in mind some allowance for the land these facilities would consume has been made in the estimates of the total areas of each of these segments. The effects of locational patterns on the routing of the railroads, or vice-versa, has not been considered.

NOTES (cont.)

35. For a study of the way in which the activities structure of American cities has come to be made up of these four kinds of specialized activity-areas, see Grossman, David A., A Theory of Urban Structure, unpublished Master in City Planning thesis, M.I.T., Cambridge, 1953. For example, on pages 2 and 3: "Briefly stated, the theory is this: that because of past developments in the nature of urban land uses, and especially because of the differentiation and specialization that has arisen among them, the land use pattern of the contemporary American city is, or is tending to become, a pattern of four basic types of land use; that these four basic types of use are residential, commercial, industrial, and recreational; that as a result of the increasing nucleation of these land uses into districts the movement of people within an urban area can be explained in terms of interactions between use-districts; and lastly, that the pattern of use districts and of the transport interactions between them is the basic pattern, or structure, of the city."

36. For an example of a metropolitan plan for developing nucleated residential communities, see Cincinnati, Ohio, City Planning Commission, Communities: A Study of Community and Neighborhood Development, 1947.

37. Though one might justify measuring the longer time-separations purely in terms of automobile travel, it was felt that some account should probably have been made of flows of people between segments by walking. However most of the walking trips will be on an intra-segment scale. Even in Plan I no two of the centers of different segments are within a 7 minute walk of each other; this movement would be faster by automobile, even with the allowance of 4 minutes for terminal time. In the evaluations of Table V some allowance was made for the fact that all separations falling in zone 1 would be less than a 15 minute walk.

38. The diagram of Figure 2 was drawn to the odd scale of 1 inch equals 1.77 miles in order to have each 1/10th-inch square space represent 20 acres. This means that each "space" of 1/10th-inch represents 0.177 miles, which could be covered in about 3/4th-minute at a speed of 14 miles per hour. The time-separation measurements listed in Table IV have been rounded to the nearest minute.

39. Isard, Walter and Coughlin, Robert E., Municipal Costs and Revenues Resulting from Community Growth, Chandler-Davis Company, Wellesley, Mass., 1957. Though "level of service" and "cost to the community" are the sort of performance indices referred to in this study, "density" is not. Density is only an abstraction that has no value in and of itself. The internal properties of activity-segments

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considered later in this chapter are measured not in terms of density but rather in terms of valued quantities such as "outdoor playspace" or "opportunity for face-to-face contacts."

40. The fact that coherent sectors of the economy are not necessarily contiguous in space has been stressed by Walter Isard in Location and Space Economy (Bibliography, No. 7), pages 13-14: "A meaningful sector is not necessarily, and perhaps only infrequently, a wedge of activities contiguous in space. It is a complex of activities where association leads to definite agglomeration economies, but where, subject to certain restraints, presence of these activities within a Greater Metropolitan Region in any of many possible patterns of scatter and concentration may more often than not satisfy the spatial associational requirement."

41. In a postwar study of regional patterns in Greece, Dr. Constantinos Doxiadis, then Minister and coordinator of the Greek Recovery Program, reached the conclusion that the only reliable basis for delineating planning regions was the pattern of movements of the population to the urban centers from which they obtained their needs.

42. For an outline of the major power groups that usually influence the development of metropolitan land use patterns and the criteria on which they base their decisions, see Form, William H., "The Place of Social Structure in the Determination of Land Use: Some Implications for a Theory of Urban Ecology", Social Forces, Vol. XXXII, Vol. XXXII, No. 4, May 1954, pages 317-323.

43. Lloyd Rodwin refers to the importance of the adaptability of various facilities in his Suggestions for Research on the Spatial Distribution of Activities...(Bibliography, No. 12); for instance, on page 17 he states: "Relative adaptability of these areas and structures to different uses also has to be examined since the possibility of conversions and more intensive use often determines the patterns that actually emerge."

44. See Carrothers, Gerald A.P., "An Historical Review of the Gravity and Potential Concepts of Human Interaction" (Bibliography, No. 2).

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